COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF INTERNAL AFFAIRS

OIL AND GAS GEOLOGY

of the

SHEFFIELD QUADRANGLE

PENNSYLVANIA

by

A. I. Ingham, W. S. Lytle, L. S. Matteson

and

R. E. Sherrill

TOPOGRAPHIC AND GEOLOGIC SURVEY

BULLETIN M 38

1956

PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES
BULLETIN M 38

OIL AND GAS GEOLOGY

OF THE

SHEFFIELD QUADRANGLE
PENNSYLVANIA

By

A. I. INGHAM, W. S. LYTLE, L. S. MATTESON
and
R. E. SHERRILL

DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, *Secretary*

TOPOGRAPHIC AND GEOLOGIC SURVEY
CARLYLE GRAY, *State Geologist*

1956

ADDITIONAL COPIES

OF THIS PUBLICATION MAY BE PURCHASED FROM

BUREAU OF PUBLICATIONS

DEPARTMENT OF PROPERTY AND SUPPLIES

HARRISBURG, PA.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PLATES

FIGURES

TABLES

OIL AND GAS GEOLOGY OF THE SHEFFIELD QUADRANGLE PENNSYLVANIA

By

A. I. Ingham[1], W. S. Lytle[2], L. S. Matteson[3], R. E. Sherrill[4]

ABSTRACT

This report on the oil and gas geology of the Sheffield quadrangle describes the surface and subsurface rocks from the Brookville coal of Pennsylvanian age to the Sartwell sand of Devonian age, the origin of the oil and gas sands, oil and gas pools, and structures mapped. Included are maps showing the oil pools, location of wells in the pools, productive sands and their thicknesses, and prominent structures.

The Sheffield quadrangle is located in Forest and Warren counties, Pennsylvania. The exposed rocks belong to the Allegheny and Pottsville series of the Pennsylvanian system, the Pocono group of the Mississippian system, and Conewango group (Upper Devonian) of the Devonian system. The total thickness of the exposed rocks is about 1100 feet.

It is believed that the first oil and gas test was drilled in the quadrangle in 1864 or 1865. Since that time over 4000 wells have been drilled in the area. Almost one-half of the quadrangle is oil and gas productive, the main producing areas are the Clarendon, Balltown, Cherry Grove, and Cooper pools whose sands have the pool names. Production is obtained from Upper Devonian sands of the Conewango, Conneaut, and Canadaway groups. Accumulation of oil and gas is controlled primarily by stratigraphic factors.

Four wells tested the deeper horizons in the quadrangle, one of which was completed in the Lower Devonian Oriskany sandstone and three bottomed in the Salina (Silurian). All four tests were dry.

A number of the oil pools have been operated under vacuum for many years but vacuum has been replaced by gas repressuring on some leases in the last few years with good results. Water flooding has been successfully applied in the Clarendon pool. Only experimental floods have been in operation elsewhere in the quadrangle, with very little success.

Since 1884 oil and gas activity in the Sheffield quadrangle has consisted largely of extending producing areas. A number of isolated and rather small pools producing from sands of the Conewango group have been found, the most recent in 1949 with the discovery being the Clough field, producing from sands in the lower part of the Conewango group. In the future, the wider application of secondary recovery methods, the possibility of discovering additional production in the southwestern and northwestern parts of the quadrangle, and the extension of present producing areas should continue to interest the oil and gas producer in this quadrangle.

INTRODUCTION

The Sheffield quadrangle is located in Forest and Warren Counties, Pennsylvania (fig. 1). Almost one-half of the quadrangle is oil and gas productive, the main producing areas being the Clarendon, Balltown, Cherry Grove, and Cooper pools. Production is obtained from Upper Devonian sands of the Conewango, Conneaut and Canadaway groups. Accumulation of oil and gas is controlled dominantly by stratigraphic factors.

The collection of data on the occurrence of oil and gas in Sheffield quadrangle was begun in 1941 by L. S. Matteson. Prior to that, S. H. Cathcart and J. F. Mason did reconnaissance geologic mapping of a part of the quadrangle in connection with northern Pennsylvania structural-stratigraphic studies. R. E. Sherrill also did surface mapping in the quadrangle and most of the surface stratigraphy section of this report has been written by him. A. I. Ingham, William S. Lytle, L. S. Matteson, and R. F. Reinhard compiled and studied the subsurface data. T. H. Jones and W. H. Seifert also compiled information contained in this report.

[1]Sup't of Lands and Geology, Peoples Nat. Gas. Co., formerly Geologist, Pennsylvania Geological Survey
[2]Chief, Oil and Gas Division, Pennsylvania Geological Survey
[3]Geologist, Hope Natural Gas Co., formerly Geologist, Pennsylvania Geological Survey
[4]Deceased, formerly Prof. of Geology, Univ. of Pittsburgh and Cooperating Geologist, Penna. Geological Survey

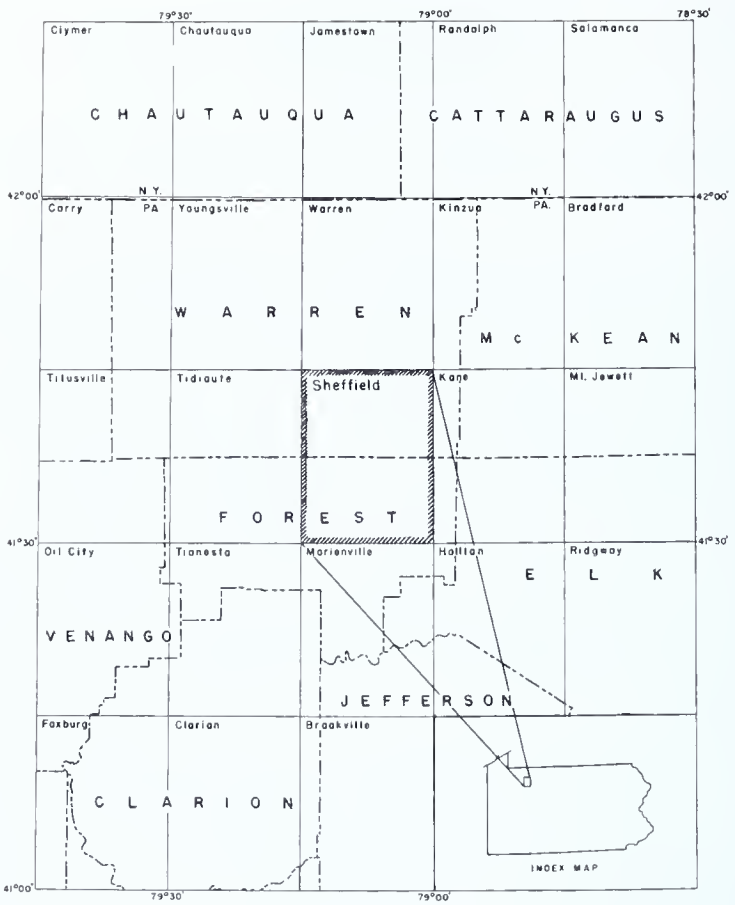


Figure 1 *Index map showing the Sheffield quadrangle.*

Except for the above-mentioned surface stratigraphy section, the report has been written by Ingham and Lytle.

Purpose of Investigation

This study of the Sheffield quadrangle is a part of the Topographic and Geologic Survey program devoted to the investigation of oil and gas resources of Pennsylvania. Detailed studies of the occurrence of oil and gas in many of the shallow fields of western Pennsylvania have already been published, principally as quadrangle reports. In response to the current high interest in the gas possibilities of the Oriskany sand of north-central Pennsylvania, a number of publications directed toward Oriskany prospects have also been issued.

A primary object of the Geological Survey's oil and gas program is to assemble data pertinent to the secondary recovery of oil. Secondary methods of oil production are highly successful in various Pennsylvania fields and have greatly extended the life of many oil-producing areas. Water, gas and air injection methods are being used with varying degrees of success in the Sheffield quadrangle. Wise planning of such production techniques requires a knowledge of geology of the area.

Another aim of the Geological Survey investigations is to assist the operator in finding new production. Although the density of drilling in western Penn-

sylvania's oil and gas belt has been heavy, there are still innumerable areas not tested or inadequately tested. The Survey's program calls for the collection of basic data essential to an evaluation of such oil and gas prospects. Many thousands of dollars have been wasted, for example, because long-forgotten dry holes have never been recorded on a map. Data on mineralogy, lithology, size, shape, and areal distribution of producing sand bodies afford valuable guides to finding new oil and gas reserves.

A third, and somewhat more abstract aim of the studies, although of potentially inestimable value, is to learn more about the origin, migration, and accumulation of oil and gas. Although the increasing use of various scientific tools is continually boosting oil and gas finding ability to new highs, fundamental research on the above three factors will aid in bettering discovery efficiency.

Method of Investigation

Field work in connection with the Sheffield study consisted of (a) geologic mapping of surface strata and (b) the gathering of well locations, elevations and records, and the interviewing of operators regarding production characteristics and primary and secondary methods of oil and/or gas production. The accompanying maps show over 4000 wells in the quadrangle. Logs were obtained on the majority of the wells and elevations of many were obtained by the altimeter method. Drill cuttings from 12 wells were examined, but no cuttings were available northeast of a diagonal line roughly extending from the southeast corner of the quadrangle to the Pleasant-Mead Township boundary of the north edge of the map.

Surface structure studies on the Corry sandstone have been completed only in the northern half of the quadrangle (pl. 2). Since the Corry, an excellent marker bed to the west, cannot be recognized with certainty in part of the Sheffield quadrangle, additional surface mapping in the southern part of the quadrangle was based on the top of the Cattaraugus formation and the interval between it and the top of the Corry. Coarse-grained to conglomerate beds in the Knapp formation and the Olean conglomerate possibly could be used. Several of the beds in the Knapp are very similar, however, and the possibility of jumping from one horizon to another must be guarded against in field mapping.

Acknowledgements

During the course of the study numerous individuals and companies willingly contributed data. It is impossible to list all the many sources of information, but we particularly wish to acknowledge aid furnished by the following: W. Floyd Clinger of the W. F. Clinger Company, John Cochran, D. E. Conaway of the Pennsylvania Gas Company, C. R. Deible of the Marienville Glass Company, H. W. Fuellhart, Bert Goal, South Penn Oil Company, and the U. S. Bureau of Mines, the latter organization having made the crude oil analyses.

The writers are grateful to Chas. R. Fettke, Cooperating Geologist with the Survey for his many helpful suggestions. Miss Lillian Heeren of the Survey staff did the drafting of illustrations accompanying this report.

HISTORY OF THE OIL AND GAS INDUSTRY

It is believed the first oil and gas test was drilled in the quadrangle in 1864 or 1865 in the Tionesta Creek Valley at the town of Sheffield. It was drilled to a total depth of 825 feet and was abandoned after encountering only a small show of oil and gas. Additional tests for oil and gas were drilled in Cherry Grove and

Watson Townships, Lots 573, 587, 665, 668, and 745, during the period 1865 to 1879. Although none of these tests were productive, some had shows.

In September 1875, Hague No. 1 was brought in as the first commercial gas well in Sheffield Township. The location of this well, described as two and one-half miles east of Sheffield "on lands of Horton, Crary, and Company", indicates it to be in the Kane quadrangle. The well had a large flow and supplied the town of Sheffield with gas for heating and illuminating purposes. Hague made a second location in 1876-77 (Lot 288 ?), between the first test and Sheffield and obtained gas, although much less than was found in the first test. The third producing gas well was completed in 1879, the so-called "Barnesville well", located in Lot 367 near Barnes.

Two small oil wells were drilled in the quadrangle in 1877. In April 1877, Grandin and Berry No. 1, located in Warrant 4821, Howe Township, Forest County, was completed in the area which, five years later, was to be extensively developed as the Balltown-Truemans pool. This well was only a small producer and it attracted little interest. In the same year the Hulings test was drilled on the Fox tract at Lynch, Howe Township, Forest County. This well was capable of producing two or three barrels of oil per day, but according to Ashburner (1885), it was soon abandoned as it was "isolated and difficult of access".

In November 1880, Blue Jay No. 1, was completed on the Fox tract, close to the Hulings test. This was the first fairly good oil well in the quadrangle and it stimulated new interest in the area. In the following Spring, Magee and Horton completed their No. 1 well on Lot 408, Sheffield Township, Warren County, with an initial production of 50 barrels a day. The Magee and Horton test, together with discoveries which had been made in the Warren quadrangle southeast of Warren in the period 1875 to 1880, appeared to open a new productive trend. From 1881 to the latter part of 1882 drilling in the quadrangle was at an all-time high and most of the major pools of the quadrangle were discovered during this period.

The Clarendon pool of Sheffield and Mead Townships, Sheffield and Warren quadrangles, was opened on January 13, 1878, by the completion of the Tolles well located on Lot 55, three-fourths of a mile southeast of Stoneham, Mead Township, Warren quadrangle. Development of the pool was both northwest toward Warren and southeast toward the towns of Clarendon and Sheffield. Much of the Sheffield quadrangle part of the pool was drilled after 1880. The town of Clarendon is approximately in the center of the pool as now developed and the producing area is known by that name.

The Cherry Grove pool of Cherry Grove Township was discovered in March 1882 by the Jamestown Oil Company's "Mystery" well on Lot 646. Carll (1883, pp. 365-367), gives a detailed account of the drilling of the discovery well. It became known as the "Mystery" well after it was shut down suddenly in March 1882 and numerous reports circulated that it had encountered a very fine oil show. Operations had been stopped in order to renew the company's leases which expired during the drilling of the test. On resuming operations in May the well was brought in with a production of 200 barrels a day. By June the production had increased to 2000 barrels a day. Such a prolific yield was certain to speed developments in the area. The initial production of a number of Cherry Grove wells was in excess of 1500 barrels of oil per day. By the latter part of August 1882, the pool was producing about 40,000 barrels of oil daily. The Cherry Grove development was very intense and wasteful, however, and by September 1882 many of the wells had stopped flowing. The production of the pool declined rapidly thereafter and the area is now almost completely abandoned.

Drilling in the Balltown-Truemans pool in Howe and Kingsley Townships, Forest County, was initiated in July 1881 by Grandin and Berry No. 2 (?), located in Warrant 3194. As mentioned previously, however, the same company's No. 1 test discovered Balltown sand oil in 1877 in Warrant 4821, but it was not until No. 2 was completed that exploitation of the pool became active. The latter test came in producing 25 barrels a day. A year later, in December 1882, Grandin and Berry completed their No. 3 with an initial production of 1000 barrels of oil per day. Most of the Balltown-Truemans pool development took place during 1883 and 1884.

At about the same time the first good wells were being found in the Balltown-Truemans pool, another discovery was made by the Shannon No. 1 located on the Cooper tract near the Forest-Warren County boundary line southwest of Henry's Mills. This well was completed in September 1882 in the Cooper sand, which at that time became stratigraphically the deepest producing sand in the Sheffield quadrangle. Like the near-by Balltown-Truemans pool, the Cooper producing area was rapidly developed in 1883 and 1884.

Between 1884 and the present, Sheffield quadrangle oil and gas activity has consisted largely of extending producing areas. A Lower Balltown sand (Watson-Duhring-Second Sand) was developed from the extreme southeast corner of the quadrangle, Jenks Township, northwest toward the Cooper pool. The Deerlick pool was discovered near the turn of the century in the northeast corner of the quadrangle. A pool producing from the Klondike sand in Sheffield and Cherry Grove townships was also opened. A number of isolated and rather small pools producing from Venango group sands have been found. At the present time most of the drilling is in the southern and southwestern parts of the quadrangle and in the Lower Balltown-Cooper producing areas of the east-central part of the quadrangle.

TOPOGRAPHY

The Sheffield quadrangle lies within the Allegheny Plateau physiographic province. The area is a rugged, dissected flat-topped plateau, having a maximum relief of 885 feet. The highest elevation, 2045 feet, is located in the extreme northeastern corner of the quadrangle; the lowest elevation is 1160 feet where the Tionesta Creek leaves the southwestern corner of the quadrangle. Most of the area is heavily forested.

The major stream of the area is the south and southwest-flowing Tionesta Creek which empties into the Allegheny River southwest of Tionesta. An anomalous feature of the Tionesta valley is the V-shaped constricted nature of the stream course between Barnes and Henry's Mills (Carll 1880, pp. 349-350; 1883, pp. 349-353), which is unlike any other part of the stream valley. Regional studies indicate this area was a stream divide during pre-glacial time. The damming of the ancestral Tionesta Creek by continental ice caused the stream to overflow at a spillway believed to have been located between Barnes and Henry's Mills. Much of the stream valley in this area, therefore, is younger than the valley to the north and south. Being younger, there has been much less opportunity for planation, and downward cutting has been dominant.

SURFACE STRATIGRAPHY[1]

With the exception of the unconsolidated glacial and stream deposits, the rocks that crop out in this quadrangle belong to the Pennsylvanian, Mississippian, and Devonian systems. The total thickness of these exposed rocks is about 1100 feet with 715 feet in the Pennsylvanian and Mississippian systems (table 1). The rocks are not well exposed. Ledges of rock crop out locally near hilltops and in road cuts but in most valley bottoms and on most of the smooth side-hill slopes, which are characteristic of the region, outcrops do not occur.

Table 1 *Rocks exposed in the Sheffield quadrangle.*

Age	Series	Group or Formation	Unit	Approximate Thickness (Feet)
Recent and Pleistocene				
Pennsylvanian	Allegheny			Approximately 50 feet presen
	Pottsville		Homewood sandstone	70
			Mercer formation	30
			Connoquenessing formation	80
			Sharon formation	60
			Olean conglomerate	40
Mississippian		Pocono	Patton formation	45 ±
			Shenango formation	200 ±
			Cuyahoga formation	
			Corry sandstone	140
			Knapp formation	

The surface rock sequence consists principally of a monotonous succession of beds of shale, sandstone, and conglomerate. Locally lenticular beds of limestone and coal occur. The exact age and correlation of some of the strata is still considerably in doubt.

The surface geology of Warren County, which includes the northern half of the Sheffield quadrangle, was mapped by S. H. Cathcart and J. F. Mason in 1941. In addition to measuring and describing all exposed sections in the northern part of the quadrangle, they ran a number of surface profiles. In these profiles the elevation and thickness of the more prominent beds were determined and the beds traced

[1]Author of the section on surface stratigraphy is R. E. Sherrill. Data relating to surface stratigraphy, but obtained from well sample studies by A. I. Ingham have also been included.

through observation on the loose surface rock fragments - the "float". This mapping by Cathcart and Mason, similar mapping by R. E. Sherrill in the southern part of the quadrangle, and the records and samples of the oil wells constitute the data used in describing the surface stratigraphy here.

Pennsylvanian System

The rocks of Pennsylvanian age in the Sheffield quadrangle consist of massive sandstones and conglomerates and of interbedded sandy shales, dark slaty shales, and thin coals. These rocks underlie the level upland throughout most of the quadrangle. Outcropping ledges of the massive sandstones cap the sides of most of the valleys but the softer shales and coals are rarely exposed. The dense forest cover prevailing over much of the quadrangle and the lenticular character of the Pennsylvanian sandstones cause much difficulty and uncertainty in mapping and correlation of these rocks, and none of them have been correlated with certainty with the type sections of southwestern Pennsylvania.

Allegheny Series

The Allegheny series of southwestern Pennsylvania extends from the top of the upper Freeport coal to the base of the Brookville coal or its underclay. It is usually about 300 feet thick and contains the important Freeport, Kittanning, Clarion, and Brookville coals and the Vanport limestone. In the Sheffield quadrangle only the lower 50 feet, approximately, of the Allegheny series is present. In the northern part of the quadrangle it has been entirely removed by erosion, but the south regional dip carries the lower part of it below the summits of a few of the highest hills near the southern boundary of the quadrangle. The best exposure of these rocks is along the highway southwest from Penoke, Jenks Township, to B.M. 1864, where the following section was measured:

Section of Lower Allegheny Rocks Exposed Between Penoke, Pa., and B.M. 1864.

Thickness in feet	
7	Brown shaly sandstone capping B.M. 1864 hill, poorly exposed.
5	Covered
25	Brown sandy shale well exposed in highway cut southwest of B.M. 1864
5	Black fissile shale
4	Covered. The float contains pieces of coal - Brookville coal horizon
6	Brookville clay exposed at 1820 elevation at intersection of highway and road to Penoke
3	Homewood sandstone, massive medium-grained

The coal called Brookville in the above section is probably the same as the coal noted by Ashburner (1885, pp. 313, 316), at about 1780 elevation on Gilfoyle Run south of Byromtown, Jenks Township, and at about 1815 elevation two miles southwest of Seldom Seen Corners, Jenks Township. He called this the Clarion coal and the underlying sandstone the Johnson Run.

Pottsville Series

The Pottsville series extends from the base of the Allegheny series to the top of the Mississippian system. Its maximum thickness in this quadrangle is

about 280 feet and consists of massive medium- to coarse-grained sandstones and conglomerates with included shale and coal layers or lenses. The Pottsville consists of the following members in descending order: Homewood sandstone, Mercer formation, Connoquenessing formation, Sharon formation, and Olean conglomerate.

Homewood sandstone The Homewood sandstone consists of sandstone and sandy shale. It is generally a medium- to coarse-grained gray sandstone, often weathering to orange yellow. The grains are well rounded. The sandstone is coarser and more poorly cemented than the underlying Connoquenessing sandstones. No pebbles were seen in it in surface outcrops, but pebbles were found in this section in the samples of South Penn Oil Company No. 1 test located on Warrant 3801, Howe Township. It was not possible to determine the exact thickness of this sandstone in any of the exposures seen. The interval from the top of the Homewood to the top of the Upper Mercer coal is about 70 feet, but this doubtless includes some of the Upper Mercer shales.

The Homewood was called the Johnson Run sandstone by Ashburner (1885). It caps several of the higher hills and plateau surfaces in the southern part of the quadrangle, as, for example, the level upland from Penoke to Byromtown, Jenks Township. North of Tionesta Creek it has been removed by erosion from all except the highest hills.

Mercer formation The Mercer formation consists of brown to black shales with irregular layers of coal and siderite concretions. Two layers of black fissile shale, with included thin coal beds, are generally present in this formation. These coals were called the upper and lower Alton coals by Ashburner (1885), who made detailed measurements of them at several localities in the southern part of the quadrangle and in the adjoining Marienville quadrangle. They are generally of poor quality, less than 3 feet thick, lenticular, and probably worthless except, perhaps, for local use. This formation crops out at many places in the vicinity of Byromtown and is doubtless present, though rarely exposed, in most of the southern part of the quadrangle.

Connoquenessing formation The Connoquenessing formation consists of hard massive sandstones and included layers or lenses of shale and sandy shale. The total thickness of this formation is about 80 feet. Two principal sandstone horizons, called by Ashburner (1885) the upper and lower Kinzua Creek sandstones, are generally present in this formation in the Sheffield quadrangle, as throughout most of western Pennsylvania. Locally, however, three or more thin, hard sandstones, apparently separated by shaly sandstone or sandy shale, constitute the formation.

The Connoquenessing sandstones are characteristically hard white or light-gray and massive. They are generally the most resistant to weathering of any of the rocks of the quadrangle, except the Olean locally. They crop out over most of the quadrangle and, as a result of their resistance to weathering, are the principal rocks preserving the plateau surface. The upper and lower Connoquenessing sandstones differ only slightly between themselves and from the Homewood. In general, however, the upper Connoquenessing is a very hard white pure, clean quartz sand. It is finer-grained, cleaner, and lighter in color, than the Homewood, and its grains are more angular than the well-rounded grains of the Homewood. The lower Connoquenessing sandstone is generally coarser, darker, characteristically arkosic, and more ferruginous than the upper. Pebble bands are common in the lower Connoquenessing. In many places, "rock cities" are formed at its outcrop with great sandstone boulders strewn along the hillside below a cliff up to 35 feet high. The Olean conglomerate forms similar cliffs and rock cities.

Sharon formation The Sharon formation is very poorly exposed in this quadrangle and at no place was a complete section found. The Sharon interval, which ranges up to about 60 feet in thickness, is occupied chiefly by shale and weak sandstones.

A thin bed of coal was seen in the Sharon at a few localities. This coal is called the Upper Marshburg by Ashburner (1885) and according to him it was formerly mined on a small scale on Little Salmon Creek about two miles southwest of Seldom Seen Corners, Howe Township, on "Coal Bank Run", which is about two miles west of Deadman Corners, Howe Township, and at two localities near Lynch (formerly called Foxburg), Howe Township. Although it is doubtless present near the plateau summits, this coal is probably too thin and impure over most of the quadrangle to be of value except for local use. It probably does not exceed three feet in thickness and is generally only one to two feet thick.

Olean conglomerate The Olean conglomerate lies immediately above the erosional unconformity at the top of the Mississippian system. Where characteristically developed, it is a massive conglomerate having a thickness of 40 or more feet. The pebbles consist principally of vein quartz, ranging up to two or more inches in diameter and are generally well rounded as contrasted with the disk-shaped pebbles of the Knapp conglomerate (Mississippian). The Olean is generally more pebbly in the lower than in the upper part. Like the Connoquenessing sandstone, the Olean outcrop in many places is a "rock-city" with great conglomerate boulders strewn along the hillside. This massive, conglomeratic phase of the Olean is well displayed on a road near B.M.1584, Kingsley Township, in the southwestern part of the quadrangle, and near Hermit Springs in the northwest part of the quadrangle.

The Olean loses its conglomeratic character in the northeastern part of the quadrangle, near Sheffield, and in the west-central part of the quadrangle at Hearts Content and southward to Tionesta Creek. In these areas it consists of a medium- to coarse-grained sandstone very similar to the Connoquenessing. Locally, as near the west edge of the quadrangle, south of Hearts Content, it appears to be completely absent.

Pennsylvanian-Mississippian Unconformity

The Pottsville series rests unconformably upon the Mississippian system. The rocks below the unconformity were tilted southward, probably folded slightly, and truncated by erosion before the Pottsville series was deposited. A major result of this unconformity is that strata in actual contact are different in different localities. In general, the uppermost Mississippian beds, present in the southern part of the quadrangle, are missing by erosion in the northern part, or conversely, the Mississippian beds encountered immediately below the unconformity become progressively younger from north to south in the quadrangle.

The Pottsville-Mississippian contact is generally covered by sandstone talus throughout most of the quadrangle. This condition prevails in so much of northwestern Pennsylvania that it has not been possible to determine accurately the amount or distribution of the relief on the pre-Pottsville erosion surface. The evidence available indicates, however, that this was a gently rolling surface with local relief, generally less than 50 feet. Probably the Olean conglomerate represents stream channel deposits in the low places on this surface and the Olean is thin or missing over the pre-Pottsville hills. The Patton shale exposure, located one and one-half miles west of the quadrangle and described below, was probably preserved on such a pre-Pennsylvanian hill. The massive Olean development in the central and southwestern parts of the quadrangle probably delimits old channels. An attempt was made to relate probable pre-Pottsville topography, as indicated by Olean development, to Mississippian structure but the results were inconclusive.

Mississippian System

The top of the Mississippian system is marked in this quadrangle by the unconformity at the base of the Pottsville sandstones. The exact position of the base of the Mississippian in northwestern Pennsylvania has long been a moot question and has been discussed at length by Fettke (1938) Caster (1934) and others. In the oil reports on the Tidioute and other quadrangles west of the Sheffield, the base of the Mississippian has been considered to be at the top of a persistent reddish-brown shale, the Riceville formation, that lies about 100 feet below the Corry sandstone. This horizon lies above drainage level along and north of Tionesta Creek and is exposed in a road cut between Kelletville and Whig Hill one mile west of this quadrangle. There it lies 25 feet below the base of the Knapp sandstone. These 25 feet of strata occupy the stratigraphic position of the shales called "Kushequa" by Caster and considered by him to be the basal beds of the Knapp and of the Mississippian system. These basal Knapp shales are lithologically indistinguishable on outcrop from the underlying Riceville, and their contact with the Riceville can be mapped only as a stratigraphic horizon, projected up or down from any available key beds. Caster included them in the Mississippian on the basis of paleontologic evidence and states that a disconformity exists between them and the Riceville. In the Whig Hill section a fine-grained bluish-gray sandstone three feet thick occurs at the base of the "Kushequa". Careful examination of the contact of this sandstone with the underlying Riceville shale reveals slight evidence of disconformity. Locally the sandstone has scoured slightly into the Riceville, but similar scour may be observed at the base of most sandstones. Much greater evidence of disconformity exists at the base of the lower Knapp sandstone or conglomerate, some 25 feet higher in the section, than was observed anywhere in the underlying shales and flaggy sandstones. Fettke (1938) in his report on the Bradford quadrangle, tentatively included the Knapp beds in the Mississippian.

Sample studies of well cuttings in the quadrangle indicate a sharp break between the base of the persistent Lower Knapp sandstone or conglomerate and the underlying shales. No distinct break was noted in the shale section. In this report, therefore, the base of the Lower Knapp conglomerate is taken as the base of the Mississippian (see cross section, pl. 4). As stated by Fettke (1938, p. 27), however, the true base of the Mississippian may be within the shale section, and the best criterion for picking the contact may be faunal (Caster, 1934, pp. 103-104) rather than lithologic.

The Mississippian, as above defined, ranges in thickness from about 200 feet to about 480 feet. Across the northern part of the quadrangle the thickness ranges from about 200 to 300 feet. In the southern part of the quadrangle it is 300 to 480 feet thick. The large thickness variations are the result of the unconformity at the top of the system. In addition to a general northward thinning by removal of upper Mississippian strata during pre-Pottsville erosion, local thinning by removal of the upper beds along Olean stream channels is present. The entire Mississippian section of the quadrangle lies above the drainage level of most of the smaller streams of the quadrangle. This would, therefore, be an excellent area in which to answer many of the perplexing questions regarding the development of this system in northwestern Pennsylvania, if the outcrops were only more plentiful. Throughout the upland surface of the quadrangle the Mississippian lies below the Pennsylvanian strata and is known only from well records and samples.

The classification of the Mississippian strata of northwestern Pennsylvania and the correlation of its various sub-divisions are only partly completed. In central-southern and northeastern Pennsylvania, the system consists of two major sub-divisions, the Mauch Chunk red shale group above the Mauch Chunk and

the upper part of the Pocono have long been considered to be absent. Their apparent absence is explained by removal during pre-Pottsville erosion. Most of the Mississippian rocks of this quadrangle were probably deposited during the approximate time represented by the Pocono group in the area of the Allegheny Front, but it seems preferable to use here the names applied to these rocks in the Oil City (Dickey, et al. 1943), Bradford (Fettke, 1938), and other oil and gas reports of the 4th Series, Pennsylvania Geological Survey.

Description of Strata

The Mississippian strata of this quadrangle are tentatively classified in descending order into Patton formation, Shenango formation, Cuyahoga formation, Corry sandstone, and Knapp formation.

Patton formation In the Oil City quadrangle (Dickey, et al., 1943), which lies about 15 miles southwest of the Sheffield quadrangle, the highest Mississippian strata consist of bluish-gray clay-shale with included lenses or layers of poorly-bedded, soft red and green shale and of fine- to medium-grained greenish argillaceous sandstone. These beds constitute the Patton formation. They are not resistant to weathering and are generally covered by talus from the overlying Pottsville sandstones. At Tionesta they occupy the interval extending from about 240 feet above the Corry up to the base of the Pottsville. Because of pre-Pottsville erosion, it is believed Patton beds are absent in approximately the northern quarter of the quadrangle.

In the Sheffield quadrangle no outcrops of the beds of the Patton formation, except some of the included fine-grained sandstone members, were found. Beds thought to be Patton, however, were found in the subsurface of several wells. Grayish-green and brown siltstone and shale at a depth of 256 to 280 feet in South Penn Oil Company No. 1, located in Warrant 3801, Howe Township, may be Patton. Red and brownish-red siltstone and sandstone at 177-184 feet in Clinger, Goal, and Logan No. 1, Lot 695, Cherry Grove Township, are also thought to be Patton. Several wells between these two, however, did not show Patton strata. Red beds, probably Patton, have been recorded in a number of Clinger Oil and Gas Company wells drilled in the southwestern part of Howe Township.

One and one-half miles west of the quadrangle in the Tidioute quadrangle, along the old road one mile northeast of Whig Hill, a fairly good outcrop of the Patton formation occupies the interval extending from 200 to 270 feet above the Corry. The Patton at this outcrop consists of thin-bedded olive-green argillaceous sandstone, interbedded with lumpy red and green shale. The red beds in this outcrop are most prominent in the interval extending from 220 feet to 265 feet above the Corry. This outcrop is in the east-central part of the Tidioute quadrangle.

Shenango and Cuyahoga formations The Shenango formation occupies the upper part and the Cuyahoga formation the lower part of the interval extending from the Corry, or its horizon, upward about 200 feet to the base of the Patton formation. In the northern part of the quadrangle, where pre-Pottsville erosion has removed the Patton, the upper limit of the Shenango is the base of the Pottsville. Since the Corry or its equivalent has not been determined with certainty in all parts of the quadrangle (see discussion below), the base of the Cuyahoga is somewhat indefinite (cross section, pl. 4).

The Shenango and Cuyahoga formations are discussed together in this report because no definite basis for separating them was found in the quadrangle. The 200 feet of strata comprising these two formations consist of interbedded dark-

bluish gray sandy shales, fine- to medium-grained yellowish to greenish-brown sandstones and thin conglomerates. Sandstone predominates in the upper - Shenango - part and shale in the lower - Cuyahoga - part of these 200 feet of strata.

A prominent brown feldspathic sandstone about 40 feet thick constitutes the top of the Shenango along Tionesta Creek. Although this sandstone is generally thin-bedded and medium-grained, local layers or lenses of massive conglomeratic sandstone occur within it. On the outcrop these conglomeratic layers form large boulders similar to and often intermingled with the Olean boulders. Where conglomeratic it can generally be differentiated from the Olean by the presence within it of flat pebbles and weathered feldspar. A large spring issues from a prominent outcrop on the road north from Minister. This is probably the medial or "B" member of the Shenango of the Oil City report.[1] It forms prominent terraces below the Pottsville along Tionesta Creek in the central part of the quadrangle and along Blue Jay and Salmon Creeks in the southern part of the quadrangle, but in the northern part of the quadrangle the basal Pottsville sandstones lie on or cut into it.

A conglomerate, 5 to 10 feet thick, consisting of small flat and rounded pebbles and lying about 150 feet above the top of the Knapp, crops out in several places north of Truemans. Another similar conglomerate lying 50 to 60 feet lower in the section was noted at several places, especially in the central part of the quadrangle. It is well exposed on the old road south from Whig Hill one and one-half miles west of the quadrangle. It there lies about 100 feet above the Corry and a similar distance below the top of the Shenango. Other thin conglomerates occur within the Cuyahoga horizon in this quadrangle, but none of them are mappable units.

The presence of conglomerates at several horizons within the Shenango and Cuyahoga formations is considered especially noteworthy because they are often lithologically very similar to the underlying Knapp conglomerates and in isolated outcrops or wells can easily be mistaken for the Knapp. Many of the difficulties in correlating the Mississippian sands in the gas fields south and southeast of this quadrangle may arise from the development of these upper conglomerates. In well samples the lowermost conglomeratic bed in the Cuyahoga located about 60 feet above the Knapp (pl. 4), frequently, but not always, contains well-rounded and frosted quartz grains. Such grains are sometimes found also in the Knapp, although the smaller quartz grains of the Knapp are more often angular to sub-angular. If the above criterion is used, it should be remembered that it refers only to the smaller grains, say 1 to 2 mm. Many of the larger pebbles of both the Shenango-Cuyahoga and Knapp sections have well-rounded edges.

The shales lying between the sandstones and conglomerates discussed above are seldom well exposed in this quadrangle. Sample studies indicate, however that the Cuyahoga of this quadrangle differs little from the Cuyahoga farther west except that the dark bluish-gray shales characteristic of it are thinner and contain more layers or lenses of fine-grained sandstone and of conglomerate than in the Oil City, Franklin, and other quadrangles to the west. A general increase in sandiness eastward in the upper part of the Cuyahoga was noted in the Oil City quadrangle by Dickey, et al. (1943). This increase has continued into and across the Sheffield quadrangle.

Corry sandstone The Corry sandstone is the principal key bed used in mapping the

[1]The upper, or 'Carl' sandstone member of the Oil City quadrangle is thought to lie within the continental facies in the Sheffield quadrangle and to be absent by pre-Pottsville erosion in approximately the northern half of the quadrangle.

quadrangle west of the Sheffield quadrangle and is fully described in the reports on those quadrangles (Cathcart, et al., 1938; Dickey, et al., 1943). It was mapped throughout most of its extent in northwestern Pennsylvania by S. H. Cathcart. He traced it across the Tidioute, Youngsville, and Warren quadrangles, to its terminus as a lithologically recognizable unit in the Sheffield quadrangle.

The Corry northwest of the Sheffield quadrangle is generally about 20 feet thick and is typically a three-fold unit consisting of two sandstones separated by shale. In the northwestern part of the Sheffield quadrangle, a thin, fine-grained yellow to light brown, very fossiliferous sandstone occurs at the Corry horizon. It is generally less than two feet thick. It is underlain by about five feet of dark gray shale. It is rarely found in place, but float from it occurs immediately above the top of the Knapp throughout most of the northwestern half of the quadrangle. It was not seen southeast of a general line extending from Sheffield to the southwest corner of the quadrangle. This thin fossiliferous bed occurs also in the southern part of the Warren quadrangle and was identified as Berea by Butts (1910). Caster considers this fossil zone to lie at the base of the Corry, but the field tracing by Cathcart makes it appear more probable that in the Sheffield and Warren quadrangles it is in the upper sand. Whether the Corry disappears eastward by non-deposition or by subsequent erosion, as was thought by Caster (1934, p. 122), or by lateral gradation into shale or into sandstones which have been called Knapp has not been determined. Its general dirtier appearance, browner color, and increased iron content eastward suggest that still farther east it may have been included as a part of the Knapp.

Correlation of sample study logs of the Oil City quadrangle with those made in the Sheffield quadrangle suggest that the Corry of the Oil City is equivalent either to the upper Knapp as shown in several logs on the cross section (pl. 4), or perhaps correlative with the section the top of which is approximately 40 feet below the top of the Knapp.

At Brookston in the Kane quadrangle, one and one-half miles east of the Sheffield quadrangle, a very fossiliferous ferruginous dark brown sandstone occurs at the top of the Knapp sandstones and conglomerates. This may be the equivalent of the Corry.

Knapp formation The Knapp, named by Glenn (1903, pp. 980-981) for the village of Knapp Creek in the Olean quadrangle, is the principal key formation used in surface mapping in the quadrangles lying east of the Sheffield. Its age and correlation have been described and discussed by Fettke (1938).

Sample studies of wells in the Sheffield quadrangle show the Knapp consists of three or more conglomeratic and sandstone beds separated by shale. The base of the lower Knapp conglomerate has been taken as the Mississippian-Devonian boundary, although as pointed out previously, the contact may be as much as 20 to 30 feet lower in the section. The thickness of the Knapp ranges from 85 to as much as 122 feet, averaging about 100 feet.

Of the Knapp conglomerates, well sample studies show the upper and the lower ones (pl. 4) to be the most persistent. The lower Knapp conglomerate is especially persistent and is characterized by its highly ferruginous character with abundant iron-stained quartz pebbles. Butts (1910, p. 5) found a similar type lithology for this unit in the Warren quadrangle.

The sandstones, which constitute the greater part of the formation, are

generally hard, fine- to medium-grained, argillaceous and ferruginous. In color, they range from light gray to dark brown. Megascopically the conglomerates are characterized by pebbles which are flat or discoidal in shape in contrast to the round or ellipsoidal shape of the Olean pebbles. Pebbles of conglomerates in the Cuyahoga and Shenango and Salamanca are flat or discoidal as in the Knapp. As noticed by Fettke (1938, p. 28), red jasper pebbles occur sparingly in the Knapp and Salamanca conglomerates but are apparently absent in the Olean.

On Bull Hill west of Sheffield, the Knapp consists of an upper fine-grained brown sandstone, 21 feet thick, separated from a 26-foot medial conglomeratic brown sandstone by 21 feet of shale. Fifteen feet lower in the section (at 1604 elevation on the old road) is a thin fine-grained hard iron-stained brown sandstone, thought to be the base of the Knapp. The Corry is not recognized in the Bull Hill section or to the south and east of there, but to the north and northwest, especially northwest of Tiona, it is present as a thin fossiliferous sandstone lying in or immediately above the upper Knapp sandstone. At Sheffield and southward it is entirely possible that the Corry horizon lies in the upper part of the highest sandstone here called Knapp. Southward from Sheffield, the Knapp becomes more massive and conglomeratic, especially in the medial portion. In the vicinity of Henry's Mills massive conglomeratic Knapp sandstone, probably the middle Knapp sandstone, is separated from seven feet of basal Knapp sandstone and conglomerate by 21 feet of shale.

At Brookston, in the Kane quadrangle, four miles southeast of Henry's Mills, the following section was measured:

Thickness in feet	
17	Sandstone, poorly bedded, argillaceous, brown, iron-stained, with included thin conglomeratic layers. Very fossiliferous at top.
10	Concealed - probably shale.
31	Sandstone and conglomerate, fairly massive.
16	Concealed - probably shale and shaly sandstone.
20	Sandstone, fine-grained, brown, interbedded with sandy shale, poorly exposed. Two feet below the top is a 6-inch layer of flat pebble conglomerate.
6	Concealed - probably shale.
10	Sandstone, irregularly bedded, dark brown, with included clay concretions; spring at base. Probably base of Knapp.

The 31-foot sandstone and conglomerate is the most massive member in the section and is probably the massive Knapp conglomerate of the Henry's Mills section and the medial conglomeratic Knapp sandstone of the Bull Hill section. It may be the upper Knapp conglomerate of the Bradford quadrangle, but its position in the type Knapp formation cannot be determined until mapping of the intervening quadrangles is completed. Large talus boulders from this massive conglomeratic member are common along South Branch and along Blue Jay Creek to one-half mile south of Watsontown Run where, at a waterfall, the conglomerate goes below drain-

age level. Along Tionesta Creek west from Lynch, conglomerate beds at the horizon of this medial member continue to and beyond the edge of the quadrangle, but in general the pebbles are smaller and the conglomerate layers thinner westward. The lower Knapp sandstones were not recognized with certainty west of Lynch and probably grade into sandy shale. On the road north from Minister, 61 feet of interbedded sandstone of Knapp lithology and thin shales is underlain by 57 feet of fossiliferous shale and sandy shale. Present here at the base of the Knapp sandstones, there is an 11-foot massive, coarse-grained to pebbly sandstone which is probably in the lower part of the massive medial conglomerate member of the eastern part of the quadrangle. Farther west in the Whig Hill-Kelletville section, Tidioute quadrangle, one mile west of the Sheffield quadrangle, sandstones of Knapp lithology occur through only 35 feet of section, contain pebble beds in the lower part, and are overlain by fossiliferous Corry.

Caster considered the Knapp beds to be the eastern equivalent of the Cussewago group of northwestern Pennsylvania. Whether his Knapp beds included the upper Knapp sandstone of this report is not certain, but it appears probable that his lower or Wetmore conglomerate is at the horizon of the lower Knapp sandstones of this report. His upper or Cobham conglomerate is the medial massive sandstone and conglomerate in this quadrangle, and the upper sandstone or part thereof which is of Knapp lithology in this quadrangle, is the equivalent of the Corry.

SUBSURFACE STRATIGRAPHY

Devonian System

Approximately 300 feet of Upper Devonian strata are exposed in the topographically lower areas of the quadrangle. Since much of the Upper Devonian was studied in well samples, however, the section is here treated under subsurface stratigraphy.

As shown by table 2 and the composite log (pl. 7), the Upper Devonian penetrated by many of the tests in the quadrangle includes in descending order the Conewango, Conneaut, and Canadaway groups.

TABLE 2. *Upper Devonian subsurface rocks in the Sheffield quadrangle.*

Group	Formation	Thickness	Members	Named Units
Conewango	Riceville (Oswayo)	95'±		
	Cattaraugus (Venango)	360'	First Sand zone Second Sand zone Amity shale Third Sand zone Tanners Hill	Venango First, Red Valley Venango Second Knox Third Stray, Knox Third, Knox Fourth, Knox Fifth
Conneaut		710'		Magee Hollow, Pink Rock First Warren, Second Warren Queen zone. (Glade in part)
Canadaway		1600'±		Clarendon Stray, Clarendon, Balltown, Cherry Grove, Tiona, Cooper Stray, Cooper, Klondike, Deerlick, Sartwell

The name Conewango group was proposed by Butts in the Warren Folio (1910) for the beds elsewhere called Oswayo and Cattaraugus. Since the latter two divisions could not be differentiated in the Warren quadrangle, the term Conewango was suggested for this part of the section. In all except the extreme northern part of the Sheffield quadrangle, however, beds of Oswayo-Cattaraugus facies can be distinguished in well cuttings (see pl. 4). In this report, however, the term Riceville formation is used in place of Oswayo formation as it is felt that it has more local significance.

The Riceville formation includes the section between the base of the lower Knapp and the top of the Cattaraugus. It consists of shales and sandstones 90 to 150 feet thick in the Sheffield quadrangle. The name Cattaraugus, a formation of the Conewango group, was given by Glenn (1903) to the succession of red and greenish-gray shales and fine-grained micaceous sandstones which underlie the Oswayo formation in Cattaraugus County, New York. In this report the Cattaraugus formation includes those strata between the first true red beds and the base of the Tanners Hill member (pl. 4). It is essentially equivalent to the Venango group of Carll (1883). Much of the red color disappears abruptly between wells 24 and 25 (pl. 4) and in the latter well only the Tanners Hill member remains of the Cattaraugus facies.

The Conneaut group includes the strata between the base of the Tanners Hill member and the base of the Queen sand zone. The group has a thickness in the quadrangle ranging from 685 to 740 feet.

The Canadaway group includes those strata between the base of the Queen sand zone and the base of the Dunkirk black shale. Very few wells in the quadrangle have penetrated the entire group. A sample study by Fettke of cuttings from W. C. Wasson, E. Collins No. 1, Warrant 3189, Howe Township, indicates the Canadaway in this well has a thickness of 1592 feet.

Conewango Group

The Conewango group in the Sheffield quadrangle has been subdivided into the Riceville and Cattaraugus formations. The Riceville formation and the Venango group in the reports on the Oil City and adjoining quadrangles (Dickey, et al. 1943) are essentially the equivalents of the Oswayo and Cattaraugus formations respectively (pl. 7).

The top of the Cattaraugus formation in the Sheffield quadrangle, as at Oil City, is the top of the First sand zone; the bottom of the formation is placed at the base of the Tanners Hill red member, which is believed to be approximately equivalent to the base of the Venango Third sand of Oil City. So defined, the Cattaraugus in the Sheffield quadrangle has a rather persistent thickness varying from 350 to 360 feet as compared with 320 feet in the Oil City quadrangle. A comparison of the subsurface sample logs of the Sheffield quadrangle with those made in the Oil City quadrangle indicates that a number of the units of the two areas can be correlated. These include the Venango First and Red Valley (Tidioute "White") sands of the First sand zone, the Venango Second sand of the Second sand zone, the underlying Amity shale, and the Knox Third, Knox Fourth and Knox Fifth sands of the Third sand zone.

The Conewango group contains the major oil and gas sands of the producing areas to the west and southwest of the Sheffield quadrangle. In this quadrangle, however, the production of these sands is of minor importance. Most of the produc-

tion here is furnished by sands of the underlying Conneaut and Canadaway groups. Conewango producing sands in the quadrangle include, in descending order, the Venango First, Knox Third Stray, Knox Third, and Magee Hollow sands. The Venango First sand is productive in only two wells in Warrant 5106, Howe Township. The Knox sands produce in scattered areas throughout the quadrangle. The Magee Hollow produces in a few wells in Lot 437, Sheffield Township, and Warrant 2980, Howe Township.

Riceville formation The Devonian strata above the First sand zone comprises the Riceville formation. In the Sheffield quadrangle it occurs about 900 feet above the base of the Pink Rock and has a thickness of 90 to 150 feet. It crops out along Tionesta Creek and is well exposed from Lynch westward. It consists, in the upper part, of dark brownish- or purplish-red shales. The upper 30 feet of these shales are especially well exposed in a fresh cut at Kelletville in the Tidioute quadrangle, 0.8 mile southwest of where Tionesta Creek leaves the Sheffield quadrangle. The shales weather to a rusty-brown color and are then indistinguishable from the shales above and below them. Only in the fresh unweathered material is the slight purplish-red tone noticeable in their color, and even then the slight difference in color between them and the other shales is not easily recognized except where they can be compared, side by side, with unweathered samples of the other shales. Five feet of brown shaly sandstone occur at the top of the Riceville in the Kelletville cut. This is the sandstone previously mentioned (p. 10) as probably marking the Mississippian-Devonian contact in that area. It is entirely possible that in the eastern part of the Sheffield quadrangle this shaly sandstone has become more massive and is there called the basal Knapp sandstone. The Riceville formation is about 90 feet thick in the Oil City quadrangle and consists of dark brownish- or purplish-red shale, known to the drillers as the "red rock", and of interbedded calcareous sandy shale.

The Riceville as exposed in this quadrangle and as encountered in wells becomes increasingly sandy downward and passes gradationally into the underlying First sand zone. At Mayburg and farther southwest for about a mile, a fairly prominent medium-grained gray sandstone outcrops near road level. This sandstone is about 200 feet below the Corry. This is the approximate horizon of the Venango First sand of the adjoining Tidioute quadrangle and is considered the bottom of the Riceville formation. This sandstone does not persist as a mappable unit over the entire quadrangle.

First Sand zone The First sand zone contains the youngest producing sand in the quadrangle. The upper part of this zone consists of thin-bedded shaly sandstones and sandy shales in which occur local lenses of fine- to medium-grained gray sandstone. The sand coarsens locally. Surface and subsurface studies show it to be a unit of erratic lithology occurring about 800 feet above the base of the Pink Rock and ranging in thickness from 30 to 50 feet.

On the surface this section is well exposed along Tionesta Creek from Lynch westward. The contact with the overlying Riceville shale is gradational. It contains shale layers or lenses indistinguishable from the Riceville shales and it grades by diminution in sand content, into the Riceville.

The sandstone layers and lenses within the upper part of this zone are in the general position of the Venango First oil sand. A prominent sand in the upper part of the zone southwest of Mayburg was mentioned under the discussion of the Riceville above. At Regan Run Bridge is the outcrop of a fossiliferous greenish-brown fairly massive medium-grained micaceous sandstone in the medial or upper part of the zone. Other similar sands in the zone crop out westward from Lynch,

but the zone consists principally of sandy shales and fine-grained sandstones or siltstones. Along the highway two-thirds of a mile north of Henry's Mills, a bed of sandy fossiliferous limestone about one foot thick is exposed. As nearly as can be determined, this bed is about 120 feet below the base of the Knapp or 220 feet below the Corry horizon. One mile farther northeast along the highway (0.3 mile west of the highway intersection at Barnes), and about 40 feet lower in the section than the limestone mentioned above, a highly fossiliferous blue fairly pure limestone, 8 feet thick, crops out in two places. This 8-foot bed of limestone is in the lower part of the First sand zone of the Sheffield quadrangle but was found nowhere except at the locality described above. The base of the Red Valley sand is taken as the base of the First sand zone.

At Truemans, one-fourth mile west of the highway bridge across Sheriff Run, S. H. Cathcart measured the following section of the First sand zone:

Thickness in feet	
10	Sandstone, medium-bedded, weathering to flags
20	Shale, dark
10	Sandstone, flaggy, gray, impure
10	Shale, gray to road level—elevation 1235'
10	Concealed
2+	Sandstone, massive, hard, yellow-gray, conglomeratic. The pebbles are small, discoidal in shape and embedded in a matrix consisting chiefly of iron-stained quartz, some clear, sub-angular quartz grains and some interstitial decomposed feldspar and mica.

The conglomeratic sandstone at the base of the Truemans section is mostly below water level in the Tionesta Creek valley, and lies about 300 feet below the Corry sandstone. It may be the outcrop of the Red Valley oil sand and therefore would be in the First sand zone. It also is in the approximate stratigraphic position of the Tuna conglomerate (Carll, 1883, p. 4) renamed Killbuck by Glenn (1903, p. 976). Its outcrop was not recognized elsewhere in the quadrangle, but it is well developed in most of the well cuttings studied and consists of fine- to medium-grained sandstone and conglomerate beds interbedded with shale. It is called the Hundred-Foot in some well records and the Second sand in others. It is not productive of oil or gas in the quadrangle. It is further considered under the discussion of Second Sand zone below.

Second Sand zone The Second sand zone is the medial zone of the Cattaraugus formation. This zone is generally called by the drillers the "Big Red" sand. In the Venango oil fields it occupies the interval extending from 320 to 400 feet below the Corry and contains two important oil sands - the Lytle, or Rosenberry, oil sand and the Venango Second oil sand. In the Tidioute quadrangle, the Lytle sand is generally called the Second sand in well records and the true Venango Second sand is called the Salt sand. Sands probably correlative with the Lytle-Rosenberry were found in the Sheffield subsurface, especially in the northwestern part of the quadrangle where a sand 10 feet thick is reported at the Lytle horizon in several of the logs. The correlation of this part of the section was less definite than the better developed Venango Second sand at the base of the zone, and therefore is not shown on the sections.

As fully explained in the Oil City report (Dickey, et al., 1943, pp. 24-27, 34-39), the productive Lytle and Venango Second sands are thought to be beach

deposits, and southeast of their productive limits they are thin, shaly and are embedded in and permeated with continental red, reddish-brown, and green shale. The Sheffield quadrangle lies in this southeastern zone in which the Second sand zone is in a continental Cattaraugus facies. A conglomerate, or as recognized by Fettke (1938), several disconnected and discontinuous conglomerate lentils in the medial position of the Cattaraugus was called the Salamanca by Carll (1883, p. 203). An upper Salamanca conglomerate, called the Pope Hollow by Carll (1883), and a lower Salamanca conglomerate, called the Bimber Run conglomerate by Caster (1934) have been recognized on the outcrop north of the Sheffield quadrangle. The upper of these Salamanca conglomerates is probably the Lytle oil sand (called the (A) member of the Second Sand by Carll), and the lower is thought to be the Venango Second sand (called the (B) member by Carll).

In the Sheffield quadrangle the Second sand zone (called Salamanca by Carll) lies above the drainage level of Tionesta Creek in the northern part of the quadrangle. Although good outcrops of it are scarce, near Tiona good exposures were found immediately above the flat alluvial terrace on which the town is built. These exposures are located 0.2 mile north of the confluence of Fourmile Run and Flat Run, and near creek level in a cut bank on the east side of the road at the south end of Sheffield. Conglomerate pebbles were not found in any of the Salamanca outcrops in the quadrangle, unless the conglomerate in Tionesta Creek at Truemans is Salamanca. In the subsurface, coarse sand grains were rarely found in the Venango Second sand (lower Salamanca bed).

The conglomerate at Truemans may represent the continental facies of the Second sand zone. Asymmetrical current ripple marks are prominent in talus pieces of the sandstone but were not found in place. Well developed mud cracks indicating periodic drying, occur in the shales of this zone. The shales are brick-red in contrast to the reddish-brown of the shales in the First sand zone. Marine fossils are apparently absent. These rocks were probably deposited as muds and sands on a flood plain such as the lower Mississippi Valley of today. The open sea lay to the northwest and along its shore were deposited the oil-productive Lytle and the Venango Second sands. This outcrop may be near the top of the Second sand zone for it is only 300 feet below the Corry horizon. This is at or above the position of the Lytle sand of the Venango oil fields.

On the highway up Bull Hill across Tionesta Creek from the outcrop described above is an old quarry in which are included six or more thin hard lenticular siliceous limestones. Some of these limestones are very fossiliferous and yield, upon weathering, a soft dirty-brown residue with abundant fossils, chiefly spirifers. One 5-inch bed of this limestone can be seen to pinch out and entirely disappear within a distance of 20 feet. This outcrop is one-half mile northwest of the Salamanca outcrop at Truemans mentioned above and lies 10 to 20 feet stratigraphically above it. It is probably a part of the Saegerstown shale which in the Venango oil fields lies between the First and Second sand zones. It is within the Saegerstown shale that oil-productive conglomerate lenses, the Red Valley, occur to the west and southwest.

The Venango Second sand lies approximately 600 feet above the base of the Pink Rock in the Sheffield quadrangle. As shown in the subsurface sample studies the Venango Second sand is at or near the base of the "Big Red" section although in going from southeast to northwest in the quadrangle there is progressively less red in the sand. In the northwestern part of the quadrangle, a sandstone 10 to 20 feet thick at the Venango Second sand horizon is persistently reported in the better logs. This sand at the Venango Second sand horizon is called the Salt sand, Tidioute sand, Second sand or the Gas sand in drillers logs. It is not com-

mercially productive but shows of oil or gas are reported from it in a few wells.

Amity shale Immediately below the Venango Second sand is a persistent dark-gray and brownish-gray 30- to 40-foot shale which is thought to correlate with the Amity shale of the Oil City report (Dickey, et al., 1943). This unit is rarely recorded in drillers logs, but could always be found in well cuttings. It is particularly useful as a marker bed to separate the Venango Second sand above from the Third sand zone below.

Third Sand zone The Third sand zone is the lowest zone in Carll's Venango Group. This zone consists of alternating beds of shale and fine-grained to conglomeratic sandstones. The sandstones in descending order are the Knox Third Stray, Knox Third, Knox Fourth, and Knox Fifth.

At the top of the Third sand zone, immediately below the Amity shale section, is a sandstone called in this report the Knox Third Stray, separated from the Knox Third sand below by 8 to 15 feet of shale and/or well cemented sandstone. The Knox Third Stray here lies about 550 feet above the base of the Pink Rock and may correlate with the Dutchmans conglomerate lens of Caster (1934, p. 84). The Knox Third Stray is a light-gray to white medium-grained to locally pebbly to conglomeratic sandstone. It is productive and is recorded in the logs of a number of wells drilled by the Clinger Oil and Gas Company in the southwestern part of Howe Township. In the extreme southeastern part of the quadrangle it appears to merge with the Knox Third.

The Knox Third Stray, the Knox Third, Knox Fourth, and Knox Fifth, are frequently called "Clarion" by the drillers, although in most instances the drillers' "Clarion" refers to the Knox Third Stray and/or Knox Third. The Third sand productive in the Clarion area to the southwest is probably correlative with a part or all of the Knox Third Stray-Knox Third of the Sheffield quadrangle. The Little Minister Stray of the Tidioute quadrangle (Cathcart, 1938, p. 9) and the drillers' "Boulder" (Dickey, et al., 1943, footnote p. 28) are believed to correlate with the Knox Third Stray.

The Knox Third sand is a light-gray and greenish-gray fine-grained to conglomeratic sandstone. It occurs approximately 530 feet above the base of the Pink Rock and is believed to correlate with the Knox Third of the Oil City quadrangle. It may possibly be the equivalent of the Tidioute Third sand although the latter appears to be somewhat lower in the section.

The Knox Third produces oil and gas in various areas throughout the quadrangle. It and the overlying Knox Third Stray also frequently contain salt water.

Several wells drilled by the Clinger Oil and Gas Company in the southwestern part of the quadrangle show not only the Knox Third and Knox Third Stray sands, but also a third sand between the two. The three sands are so close together that it is impossible to tell whether the middle one represents a split of the Knox Third Stray or Knox Third, or if it is actually a separate sand.

The Knox Fourth and Knox Fifth sands lie about 505 and 480 feet respectively above the base of the Pink Rock and are believed to correlate with sands of the same name in the Oil City quadrangle. Both are fine-grained to locally pebbly and conglomeratic sandstones. Neither one is oil and gas-productive in the Sheffield quadrangle. The Knox Fifth is frequently red in color and is often found in the upper part of the Tanners Hill member described below.

*Tanners Hill member*One of the most persistent lithologic units in the quadrangle is a 15 to 35-foot bed of red shale and siltstone (pl. 4) with some sandstone found near the base of, or just below the Knox Fifth sand. The red strata were called the "Tanners Hill red band" by Carll and Randall (1883) and named after the type locality at the Tanners Hill quarry in Warren, Pennsylvania. The top of the Tanners Hill member varies from 100 to 127 feet, averaging 115 feet, above the top of the Pink Rock, another excellent marker in the Sheffield quadrangle. This member is not only a persistent unit in this quadrangle but its correlative has also been found in well cuttings as far east as eastern McKean County (Dickey, et al., 1943, Fettke 1938) and west to the Oil City quadrangle. It may also be present in southwestern Pennsylvania. This unit is taken as the base of the Cattaraugus as it is at the bottom of the Upper Devonian red section and is probably close to or just below the Wolf Creek (Panama) conglomerate zone (Caster, 1934, p. 78). It is not productive in the quadrangle.

Conneaut Group

The Conneaut group in the Sheffield quadrangle is predominately siltstone and shale. Although three sands in this group are productive in the quadrangle, they are relatively unimportant. This group includes in descending order the following named units: Magee Hollow sand, Pink Rock, First Warren sand, Second Warren sand and Queen zone. It is about 710 feet thick in this area.

Magee Hollow sand The section below the Tanners Hill member to the top of the Pink Rock, consists of approximately 100 feet of shale and siltstone. A thin, very rarely developed sandstone, known as the Magee Hollow, has been found near the middle of this interval in a few areas. The character of the Magee Hollow sand in the producing area (Lot 437 and Warrant 2980) has not been recorded in drillers logs but its character can be seen in the samples of South Penn Oil Company No. 1 Warrant 2993, Howe Township. It is fine-grained and tight in this well. The Magee Hollow sand lies about 410 feet above the base of the Pink Rock.

*Pink Rock*The Pink Rock of the Conneaut group and the Tanners Hill member of the Conewango group described above are the most persistent lithologic units in the quadrangle. The Pink Rock consists largely of siltstone and shale. Small amounts of fine-grained sandstone are frequently found in the middle part and toward the base of the section. The dominantly purplish-gray color, but with some interbedded greenish-gray and medium gray, is difficult to detect unless the rock is moistened. In examining well samples under water the sharp break in color between the Pink Rock and the section immediately above and below is very pronounced. The color "pink" is a term adopted by the drillers. It is possible the mud slurry created in drilling operations shows a pink hue.

One of the remarkable features of the Pink Rock is its constancy of thickness. In a series of cutting samples of eight wells between the extreme southeastern corner and the northwestern corner of the quadrangle, a distance of about 20 miles, the thickness was found to be never less than 346 nor more than 356 feet. Throughout the quadrangle, in drillers' logs, the thickness is usually recorded from 330 to 350 feet. Where much greater or much less thickness is recorded, it appears likely that the top and/or bottom driller's pick is inaccurate.

Although the thickness of the unit is very constant, the actual amount of the Pink Rock which is purplish-gray in color becomes progressively greater in going from southeast to northwest. For instance, in the southeastern corner of the quadrangle approximately the upper and lower third of the Pink Rock section is dominantly purplish-gray whereas the middle third is mainly greenish-gray and

medium gray. This middle third, as well as the upper and lower thirds, becomes progressively more purplish-gray until, in the samples of Sloan and Zook No. 1, Lot 570, Watson Township, the entire Pink Rock section is dominantly purplish-gray in color.

The Pink Rock is found east to McKean County, west to Venango County, and may be equivalent to purplish-gray strata found below the "McDonald" Fifth sand in Washington County, southwestern Pennsylvania.

The Pink Rock is abundantly fossiliferous, especially near the top, middle, and base of the unit. It is a part of the Chadakoin stage of Chadwick (1924) (Caster, 1934). The faunal assemblage of the Chadakoin has been published in part by Caster (1934, pp. 65-66).

The base of the Pink Rock is the reference horizon of the cross sections (pls. 4 and 5) and the contour horizon of the subsurface structure map (pl. 1).

First Warren sand In the northern part of the quadrangle, immediately below the base of the Pink Rock, a thin fine-grained sandstone, the First Warren sand, is sometimes developed. It has a thickness of 0 to 15 feet. In some of the well samples the top of the sand was found to be within the lower few feet of the Pink Rock section. The First Warren is not productive in the Sheffield quadrangle. Below the base of the First Warren to the top of the Second Warren, the section consists of medium gray and dark gray siltstone and shale.

Second Warren sand The Second Warren is an erratic fine- to medium-grained, locally pebbly sandstone of varying occurrence, the top of which is 80 to 105 feet below the base of the Pink Rock. It has a thickness varying from zero to 50 feet with an average of 22 feet. The sand yields only small amounts of gas in a few wells in the quadrangle.

Queen zone The interval between the Second Warren and Queen zone is occupied by approximately 80 feet of medium-gray and brownish-gray shale and siltstone and greenish-gray fine-grained sandstones. A highly fossiliferous zone is frequently found near the base of this section.

The Queen zone consists of a number of highly lenticular and lithologically very variable sandstones, and interbedded siltstones and shales having a thickness of 80+ feet and found between 180 to 260 feet below the base of the Pink Rock. The driller commonly refers to the zone as the "80 Foot" or "Rubber Rock". The sands are light-gray fine- to medium-grained, occasionally approaching coarse grains in size. The type locality of the Queen zone is the vicinity of the village of Queen, Tidioute quadrangle. The base of this zone is taken as the base of the Conneaut group. The lower part of this zone, called the Glade sand, first produced in Beatty No. 1, drilled at Glade, Glade Township, Warren quadrangle in March 1875 and was the first commercial well in the quadrangle. This sand possibly correlates with the Bradford First sand of McKean County which in turn is approximately correlative with the Cuba sandstone (Fettke, 1938, p. 147) as developed near Cuba, Allegany County, New York.

The Queen zone is a relatively unimportant producer of gas and oil in the Sheffield quadrangle although it is the main gas-producing zone of the Tidioute quadrangle immediately to the west.

Canadaway Group

The Canadaway group in the Sheffield quadrangle is 1600 feet thick. This group contains the important oil and gas producing horizons in the area. The sands in this group are better developed than the sands in the Conewango and Conneaut groups described above. The named members in the Canadaway in descending order are: the Clarendon sands, Balltown sands, Cherry Grove sand, Tiona sand, Cooper sands, Klondike sand, Deerlick sand, Kane sands, and Sartwell sand.

Clarendon Stray and Clarendon sands Between the base of the Queen zone and the top of the Clarendon Stray are approximately 30 to 60 feet of light-gray and medium-gray shales and silstones with rare fine-grained sandstones.

The Clarendon Stray sand is recorded in only a few wells. In the samples of South Penn Oil Company No. 11, Warrant 3672, Jenks Township, the Stray was found to be light-gray in color, and fine to coarse grained. It has a thickness of 0 to 18 feet, averaging 12 feet, and its top is about 290 feet below the base of the Pink Rock. The Stray sand produces gas only in an area east and southeast of Sheffield. Between the base of the Stray, where present, and the top of the main Clarendon sand, is a 10± foot break of tight sand or sandy shale and siltstone.

The Clarendon sand is the main oil-producing sand in the neighboring Warren quadrangle and is also one of the most important producers in the Sheffield quadrangle. It is a light-gray, fine-grained to pebbly sandstone varying in thickness from 0 to 30 feet, averaging 18 feet. In its productive areas it has one to four feet of tight cap rock at the top, below which the oil is found. The top of the Clarendon is encountered at a rather constant interval close to 325 feet below the base of the Pink Rock.

The driller frequently logs the Clarendon sand as "Tiona" in the vicinity of the village of Tiona, northern Sheffield quadrangle. In all cases, in this area, the "Tiona" is synonymous with the Clarendon. This is not to be confused, however, with the Tiona sand, which is productive in the southern part of the quadrangle and in other areas to the south and west, for this sand is some 170 feet below the Clarendon sand (see composite section, pl. 7).

The Clarendon sand is well developed in the northern part of the quadrangle. The producing belt, where it enters the quadrangle, is about four miles wide in the vicinity of the town of Tiona. The productive zone tapers to a width of one-half mile about five miles south of Bull Hill (pl. 8).

Balltown sand The Balltown sand, named after the village of Balltown, Howe Township, consists of an upper and a lower member, both of which produce oil and gas. The Watson, Duhring and Second sands, productive in the southeast and east-central part of the quadrangle, are different names for the same sand which is correlative with the lower Balltown.

Approximately 25 feet of sandy shale, siltstone, and fine-grained sandstone separate the Clarendon sand from the top of the Balltown. The Balltown is found approximately in the middle of a 120-foot sand-shale-siltstone sequence comprising, in descending order, three important oil and gas sands— Clarendon, Balltown, and Cherry Grove. Many of the operators consider the Balltown sands to be below the Cherry Grove rather than above. The stratigraphic succession as set up in this report--Balltown being the younger sand—is based on detailed cross section control. Since the Balltown and Cherry Grove sands are close together it is only by such detailed correlations that their age relationships can be determined. Both the

upper and lower Balltown are fine-grained to pebbly and conglomeratic, light-gray to white sandstones. The two sands are separated by 10+ feet of sandy shale or tight sand. The thickness of the upper sand varies from 0 to 35+ feet, averaging 20 feet. The thickness of the lower sand ranges from 0 to 34 feet, averaging 18 feet. The top of the upper Balltown varies from 350 to 370 feet and the top of the lower Balltown from 385 to 395 feet below the base of the Pink Rock. In many wells in the southeast and east-central part of the quadrangle both members are recorded at intervals of 35 to 40 feet from top to top.

The well-known Speechley sand, productive in the Oil City quadrangle and in other parts of western Pennsylvania, is believed to be correlative at least in part, with the Balltown sands.

In the vicinity of Warrants 3192, 3193, 3198, 2735, and 2877, Howe and Sheffield townships, the driller frequently logs an unusual thickness of Balltown sand—75 to 110 feet in some wells (pl. 5, section BB' and pl. 8). It is believed that, rather than an actual thickening of the Balltown, the thickened sandstone section represents a merging of the Balltown and Cherry Grove sands. An interesting point is that the Cooper sand, described below, also thickens in the same area. There may be several reasons for the thickening of the sands in this vicinity. Examination of the subsurface structural map (pl. 1) shows that a northeast-southwest trending anticlinal high is present in this vicinity. If the high was in existence during the deposition of the Balltown-Cooper sands as a topographic high, it may have permitted a better wave-current winnowing of the sand at the time of the sand deposition. The structural high, being above the surrounding depositional area, would be subject to more vigorous wave-current processes and permit not only the deposition of more sand, but also cleaner sand.

Oil and gas production from the Balltown sands occur in two well defined bars of sand (pl. 8). One bar extends in a northeasterly direction for ten miles from a point about two miles southwest of Mayburg to within about two miles of Henry's Mills and curving to the southeast. North and south of this bar are several isolated Balltown sand pools. This bar is known as the Balltown-Truemans pool and is younger in age than the one to the southeast. The southeastern bar known as the Watson-Duhring pool, is about eight miles long extending from the southeast corner of the quadrangle in a northwesterly direction to the vicinity of Henry's Mills where it curves to the northeast and east. North and west of the northern tip of this bar are several oil and gas pools in this older Balltown sand. The above bars resemble a compound recurved spit such as that at Presque Isle today.

Cherry Grove sand Approximately 20 to 40 feet of fine-grained sandstone and sandy shale separates the Balltown sands from the Cherry Grove sand. The Cherry Grove sand, named after the village and township of the same name, is the main producing sand in Cherry Grove Township. The so-called Gartland sand of the Warren field is equivalent to the Cherry Grove sand. The top of the Cherry Grove is found approximately 425 feet below the base of the Pink Rock, and the sand has a thickness of 0 to 30 feet, averaging 18 feet.

Little is known about the character of the sand, as most of the pool was abandoned many years ago and very few well records are available. As encountered in Booth No. 1, Lot 660, a dry hole on the east edge of the pool, the sand is 24 feet thick and consists, in descending order, of five feet of fine-grained sandstone, five feet of coarse-grained sandstone, and 14 feet of fine-grained sandstone and sandy shale. The correlative of the Cherry Grove was found in most of the well samples and usually contains one or more thin coarse-grained sandstones, but outside the

Cherry Grove field proper rarely has oil or gas shows, even in its coarser phases.

The productive Cherry Grove sand extends from the vicinity of Hermit Spring in Cherry Grove township in a northeasterly direction for about six miles where it leaves the Sheffield quadrangle. The producing area is about two miles wide at its widest part (pl. 9).

Balltown-Cherry Grove stratigraphic relationships are discussed in the Balltown section above. The two sands are close together in the section and are frequently misnamed by the driller.

Tiona sand An interval of approximately 50 feet, consisting chiefly of sandy shale and siltstone with rare fine-grained sandstone separates the Cherry Grove from the Tiona. The character of the Tiona sand is not described in the few drillers' logs which record it. As seen in several sample logs, the Tiona consists of a light-gray very fine- to fine-grained sandstone with sandy shale. The Tiona sand produces gas only from several areas in Jenks Township.

Cooper Stray and Cooper sands Approximately 50 to 90 feet of shale, sandy shale, siltstone, and fine-grained sandstone separates the Tiona from the Cooper Stray-Cooper sand zone. The sands are named for the Cooper tract, Howe Township. Of the sands considered in the report, this zone is among the most erratic lithologically and in stratigraphic position. The top of the Cooper varies from 585 to as much as 630 feet below the base of the Pink Rock. A part of this variation may be due to driller's error in calling the top of the Cooper Stray sand "Cooper". Nevertheless, this part of the section does show considerable vertical and horizontal facies changes. The zone, therefore, is poor as a structural-contouring horizon. It is thought, for instance, that the top of the Cooper sand drops lower and lower in the stratigraphic section in going from the general vicinity of Henry's Mills northwest toward Lots 402, 403, and in going northeast-southwest on trend with these lots. Contours on top of the sand in the area would show a pseudo-anticline which would not reveal the true structure, for the apparent anticline is actually the result of a facies change.

The thickness of the Cooper Stray varies from 0 to 25 feet, averaging 20 feet; the thickness of the Cooper varies from 0 to 50+ feet, averaging 24 feet (pl. 9).

The Cooper Stray as seen in well cuttings is usually a light-gray, rarely a medium- to dark-brown fine-grained slightly fossiliferous sandstone. Up to 25 feet of siltstone and shale with varying amounts of fine-grained sandstone separates the Cooper Stray from the Cooper. The Cooper is a light-gray to commonly reddish-brown fossiliferous fine- to coarse-grained to pebbly sandstone. The reddish-brown phase of the sand is called "Red Cooper" and the light-gray "White Cooper" by the driller. Locally the red and light-gray Cooper sands show some uniformity of distribution. Considering the regional aspects, however, the color change from one locality to another is very erratic. The operators report that the "White Cooper" is coarser and where productive, usually has a greater daily oil yield than the "Red". The latter sand, however, frequently has the more sustained production. In the application of secondary recovery methods, the "White" sand has been successfully repressured with air and gas. The "Red", on the other hand, has not been repressured successfully perhaps because of its finer grained, tighter, and "dirtier" nature.

Based on its productive acreage (pl. 3 and 9) the Cooper is the most important oil and gas sand in the quadrangle. It is not productive west of the Sheffield quadrangle. Its equivalent, the Harrisburg Run, produces east of the quad-

rangle. In the Sheffield quadrangle it extends from Hastings for about 11 miles to the northeast where it crosses into the Kane quadrangle. The productive area is about two miles wide at its widest part about two miles northeast of Hastings where the productive sand divides into two lobes. One lobe about half a mile wide extends through the town of Sheffield and the other lobe about one and one-half miles wide extends through Donaldson. Where the productive lobes leave the quadrangle they are separated by a non-productive Cooper zone about two miles wide where the Cooper averages ten feet thick.

Klondike sand From 20 to 50 feet of shale, sandy shale, and siltstone separate the Cooper from the next older producing sand, the Klondike. This sand is somewhat similar to the reddish-brown Cooper in appearance, being of the same color although as observed in a number of well samples, it is finer grained than the Cooper. The Klondike varies in thickness from 0 to 15 feet, averaging 10 feet. The top of the sand occurs approximately 665 feet below the base of the Pink Rock.

The main oil and gas producing area is in Sheffield and Cherry Grove townships just southwest of Austin School where the sand body is about three miles long and one-fourth mile wide. The trend here is northeast and southwest. Two small Klondike oil pools and one gas pool are located near Austin School and Bull Hill northeast of the main producing area. The Klondike is also productive in a few scattered wells northeast of the above pools.

Deerlick sand Between the Klondike and the next deeper producing sand, the Deerlick, are approximately 50 feet of shale, sandy shale, silstone, and fine-grained sandstone. The lithologic character of the Deerlick is not described in the drillers' logs which record it, but sample studies of a well drilled in Warrant 3672, Jenks Township, showed it to be a light-gray moderately fossiliferous fine-grained sandstone. The cross section (pl. 5, BB') shows a stray sand, slightly higher stratigraphically than the main Deerlick, which is here called "Deerlick Stray". Both sands are called Deerlick in drillers' logs although they do not appear to be correlative. The sand is named after Deerlick Run, Sheffield Township.

The two main producing areas are located in the northeast corner of the quadrangle. Warrant 167 contains a small Deerlick gas pool, while due east of this pool is a small Deerlick oil pool which extends into the Kane quadrangle. Scattered gas wells to the southwest produce from the Deerlick sand.

Sartwell sand Between the Deerlick sand and the Sartwell sand, stratigraphically the deepest producing sand in the quadrangle, the section consists of approximately 450 feet of shale and siltstone with minor amounts of sandstone. Fossils are common in this section. In this interval are a number of sands, namely the Bradford Third, Lewis Run, Upper Kane and Lower Kane sands, which are productive north and east of the Sheffield quadrangle, but are not developed in this quadrangle. The name Sartwell is a tentative correlation suggested by Fettke for the term "Elk" sand which is loosely used by the driller for various sands found approximately 400 to 500 feet below the Deerlick sand and is productive in the southeast corner of the quadrangle. Although this is long range correlation, the type locality of the Sartwell sand is McKean County, it is believed preferable to tentatively name the sand Sartwell than to continue to use Elk for any one of several sands, the correlation of which has not been established with Elk County producing sands.

The top of the Sartwell occurs approximately 1200 feet below the base of the Pink Rock. This sand in a producing well in Warrant 3672, Jenks Township, is reddish brown (similar to the Cooper) and fine grained.

Elevations in feet above sea level
Contour interval 50 feet

STRUCTURE MAP ON TOP OF CORRY SANDSTONE
SHEFFIELD QUADRANGLE, PA

Pennsylvania Geological Survey
4th Series
Bulletin M 35
Plate 1
1955

A sand which is occasionally found about 100 feet below the Sartwell in the Sheffield quadrangle occupies the position of the Haskill sand which is productive in northeastern McKean County but is poorly developed and non-productive in this quadrangle.

GEOLOGIC STRUCTURE

Regionally, the Sheffield quadrangle lies in the northern part of the Appalachian foreland and in the northwestern limb of the huge synclinorium which plunges toward southwestern Pennsylvania. The quadrangle is marked by numerous northeast-southwest to north-south trending folds of relatively low relief which contrast with the more intense folding of the eastern part of the foreland and the gentler structure of the areas to the west of the quadrangle. No faulting, either in the surface or the subsurface has been observed in the quadrangle.

It will be observed that the structure as shown on the surface map (pl. 1) apparently is far less irregular than that shown on the subsurface map. This is somewhat illusory as the subsurface map is based on hundreds of well data whereas the surface contours are drawn on less and much more widely scattered data. Because of this additional data it was possible to use a 20-foot contour interval on the subsurface map. The surface map, therefore, reveals only the general structure with many of the irregularities which probably exist being "smoothed out".

Surface Structure

The surface structure map (pl. 1) is contoured on the top of the Corry sandstone, a useful marker datum on which several (Dickey 1941, Dickey, et al. 1943, Cathcart 1938) of the Survey's published surface structural maps are based. As pointed out in the discussion of the surface stratigraphy, however, the Corry is not recognizable with certainty in all parts of the Sheffield quadrangle. In view of this uncertainty, it is possible that there may be some error in the surface structure as mapped, although such error probably is less than 30 feet.

A comparison of the surface and subsurface structure maps (pls. 2 and 1), shows that the regional dip is similar in direction, slightly west of south. The amount of this dip is approximately the same on the Corry and on the base of the Pink Rock (subsurface map), about 30 feet per mile.

In addition to the regional dip of the surface beds, the most prominent features on the map are: the anticlinal nose in the southwestern part of the quadrangle, the syncline extending northward from the vicinity of Penoke, Jenks Township, and a rather vaguely defined anticlinal arch, in Pleasant, Mead and Cherry Grove Townships in the northwestern part of the quadrangle.

The syncline is a part of the "Kane basin" of Ashburner (1885, pt. 2, pl. 1). The nose in the southwestern part of the quadrangle, which actually has closure on the subsurface map, may be an extension of the Millerstown anticline of Chance (1880). Since surface work has not been done in the Marienville quadrangle, the relation between the Millerstown structure and the structure in the southwestern part of the Sheffield quadrangle has not been determined. The arch in the northwestern part of the quadrangle is a southwest extension of a structural high defined by Butts (1910) in the Warren quadrangle.

The unusually wide spacing of contours between the 1600 and 1500 foot lines in Cherry Grove and Sheffield Townships may be due wholly or in part to the difficulty of picking the top of the Corry. Obviously an error of 20 to 30 feet in

determining this datum could cause a considerable change in the contour spacing.

Subsurface Structure

The subsurface structure, contoured on the base of the Pink Rock, is shown on Plate 1. The Pink Rock was usually not recorded in the older wells, so most of the Pink Rock elevations were calculated by interval to various horizons.

As in the surface contours on Plate 2, the dip as shown on the subsurface map is slightly west of south at about 30 feet per mile.

The most prominent features on the subsurface structure map are (1) the "twin" anticlines in the southwestern quarter of the quadrangle, (2) the syncline in Jenks Township near Penoke, extending northeast through Warrants 2018 and 2021, (3) the broad arch in Cherry Grove and Watson Townships and the accompanying syncline in Watson Township, (4) the south-plunging anticline coinciding closely with the Clarendon field in Sheffield Township, (5) the dome in southwestern Howe Township, and (6) the numerous structural crenulations shown along the east edge of the map and in Howe Township east of Deadman Corners.

As pointed out in the discussion of the surface structure, the structural high or highs in the southwestern part of Howe Township may be an extension of the Millerstown anticline of Chance (1880). Of the twin anticlines shown here, the easternmost of the two is the major feature and extends northeast through the vicinity of Hastings, the southeastern part of Cherry Grove Township, and may connect with the south-plunging anticline in the Clarendon pool area west of Sheffield.

The syncline passing through the vicinity of Penoke is a part of the Kane basin (syncline) of Ashburner (1885, pl. 1), which he shows extending from a point several miles east of Marienville, Forest County, to the town of Kane.

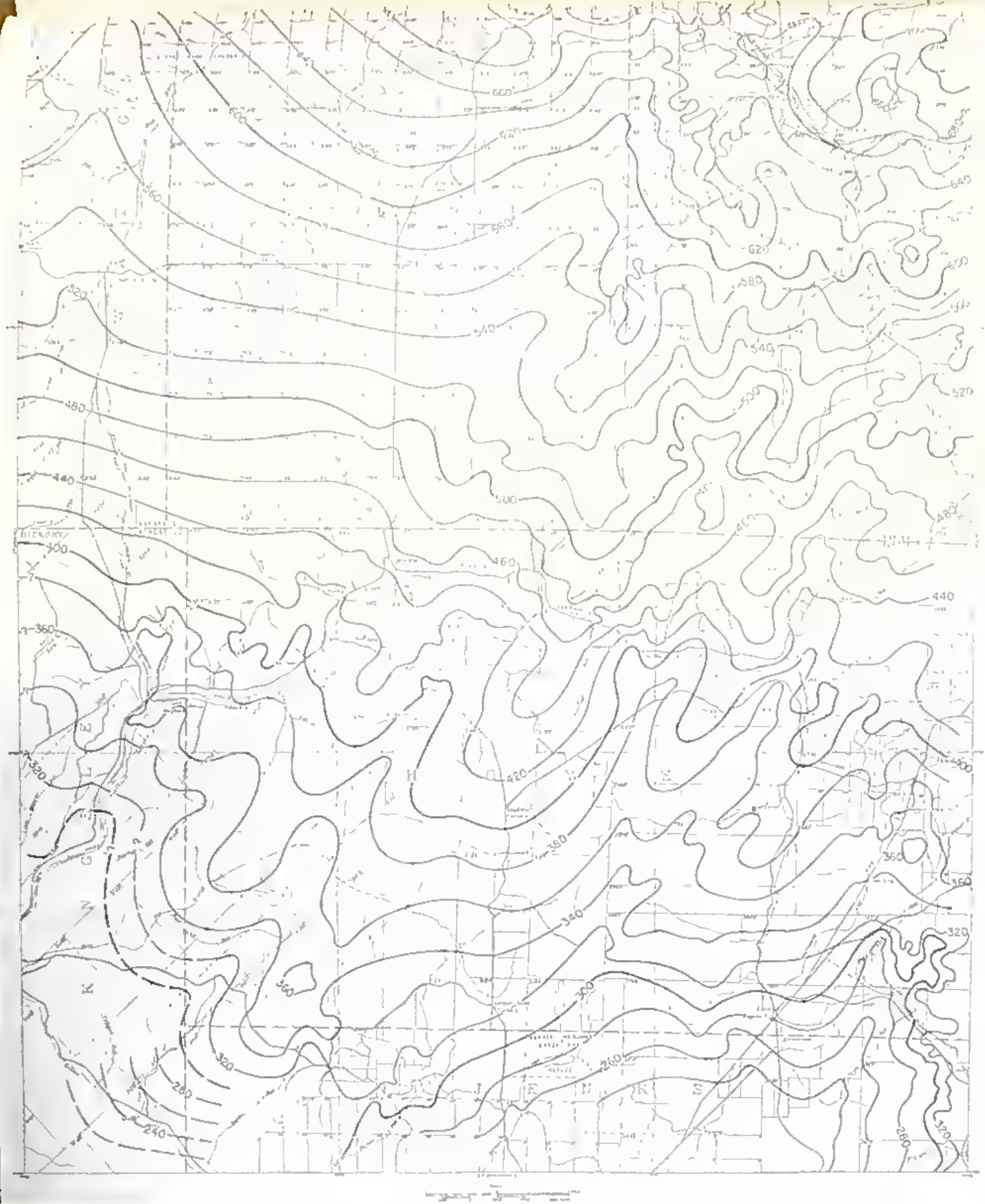
The broad arch and syncline in Cherry Grove and Watson Townships is a continuation of the structural features mapped by Butts (1910) in the southern part of the Warren quadrangle.

The south-plunging anticline in the Clarendon pool area west of Sheffield does not continue into the Warren quadrangle according to Butts' (1910) mapping. As mentioned below, however, this anticline may be an extension of the more prominent structural high located in the southwestern part of the Sheffield quadrangle.

The doming in southwestern Howe Township has just recently been determined from information obtained from wells drilled in that area during the last five years.

The numerous structural crenulations shown along the east edge of the quadrangle and in Howe Township east of Deadman Corners, appear to be rather restricted in extent although structural studies in the Kane and Kinzua quadrangles may indicate that some of the features extend considerably into these areas. Fettke's (1938, pl. A) structural map of the Bradford field shows two southwest-plunging anticlines which may be represented by similar but smaller features in the northeastern part of the Sheffield quadrangle.

Ashburner (1885) mapped the Brookston anticline extending northeast-southwest through Brookston (Kane quadrangle). Ashburner's anticline coincides rather closely in part with the anticline whose axis is shown in the eastern part of Warrant 2978. In the present study, however, no evidence was found to continue it



MAP SHOWING

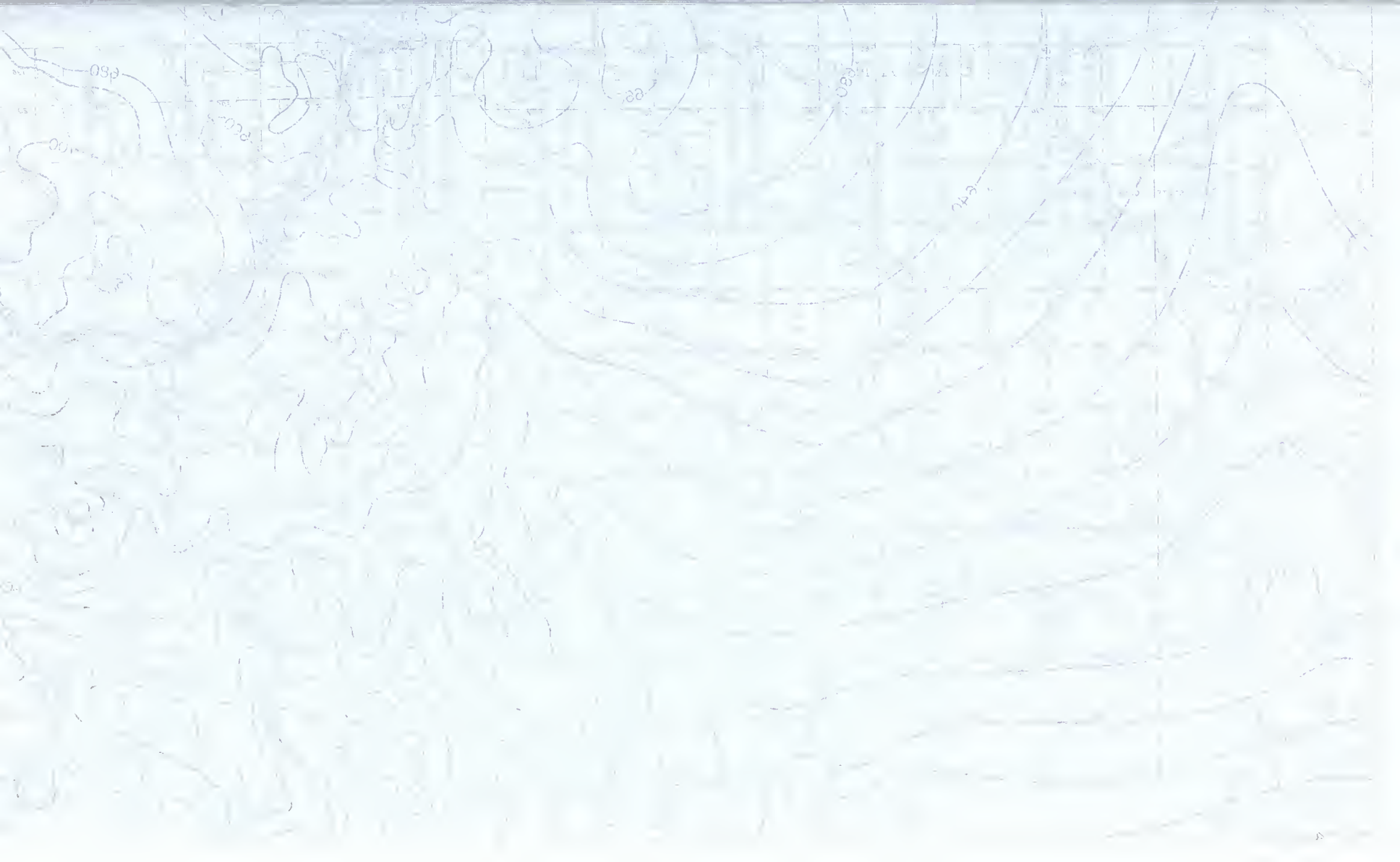
SUBSURFACE STRUCTURE CONTOURED ON BASE OF PINK ROCK

SHEFFIELD QUADRANGLE

Elevations in feet above sea level

Contour interval 20 feet

Pennsylvania Geological Survey
4th Ser.
Bulletin M35
Plate 2
1955



on to the southwest into the Marienville quadrangle as mapped by Ashburner.

In examining the subsurface structural map as a whole, it is to be noted that the amount of structural detail becomes less in going from the eastern part of the quadrangle to the northwest. Although this is in agreement with what might be expected from regional considerations, the amount of structural detail that can be shown is in direct proportion to the amount of data available. Much more data is available in the eastern part than the western part of the map. Conclusions as to diminishing intensity of structure from east to west, therefore, must be drawn with the above factor in mind.

ORIGIN OF THE OIL AND GAS SANDS

A detailed study of the origin of the oil and gas sands was not made in connection with this report. Such an investigation would involve more extensive studies of the petrology of the sands, including mineralogical composition with heavy mineral and insoluble residue analyses, grain sizes and shapes, color, texture, as well as the larger overall features of the horizon such as shape of the sand bodies, areal distribution, horizontal and vertical relations with surrounding rocks, etc. Since the important sands of the quadrangle have not been studied in adjacent quadrangles, any definitive conclusions as to their origin without the regional picture, would be premature. A few generalizations regarding the origin of the pre-Pink Rock sands are, however, given below.

Samples of pre-Pink Rock sands of the Sheffield quadrangle, from the Deerlick sand up to the First Warren all show marine fossils, chiefly brachiopods and pelecypods. Every sand is not fossiliferous in every set of samples, but each of the producing sands has in one area or another been fossiliferous. The First and Second Warren, Queen, Clarendon Stray, Clarendon, Cooper Stray, Cooper, Klondike, and Deerlick contained fossils in every sample set studied. The Balltown, Cherry Grove, and Tiona are fossiliferous in some wells and not in others. The associated shale and siltstones are also often found to be fossiliferous. It appears, therefore, that the pre-Pink Rock sandstones from and including the Deerlick to the First Warren were deposited mainly under marine conditions. The unfossiliferous portions of the sandstones may represent deltaic, beach, or near-shore continental deposits.

The pre-Pink Rock sands from the Tiona up to and including the First Warren are all light-gray to white clean quartz sandstones. These do not have the characteristics of deltaic sands where a certain amount of "dirtier" material may be expected. They are probably either (1) sands deposited seaward from the deltaic environment or (2) beach sands. Deposits of the beach environment are ephemeral in character and special conditions are needed for their preservation. The Balltown pool in the southwestern part of the quadrangle has an outline and distribution strongly suggestive of an offshore bar. The abrupt widening of the Balltown productive area in the vicinity of Warrant 3195 near Minister is suggestive of landward extension of the bar by the action of longshore currents. Matteson (personal communication) has mentioned the similarity between the Balltown trend and Presque Isle, an offshore bar extending into Lake Erie and well shown on the Erie, Pennsylvania, quadrangle sheet. The Watson-Duhring development of the Balltown sand is almost normal to the previous mentioned Balltown trend and to the common northeast-southwest orientation of many Upper Devonian producing sands. This latter Balltown trend may represent an inlet through which vigorous northwest-southeast waves and currents carried sand and at the same time winnowed them of fine silt and clay particles.

The Cherry Grove may also be an offshore bar deposit with seaward and landward extensions northwest and southeast of the control port of the bar.

The Clarendon sand is possibly of a more seaward phase than the offshore bar, laid down as more or less of a blanket deposit. The more porous and permeable parts of this deposit are the present productive area.

The distribution of the sandstones of the Cooper zone is suggestive of the coalescence of two offshore bars, merging in the vicinity of the southeastern Cherry Grove and southwestern Sheffield townships. The thickened Cooper sand zone, discussed under subsurface stratigraphy, is in this area of the two merged Cooper trends.

The foregoing suggestions as to the origin of various pre-Pink Rock sands productive in the Sheffield quadrangle are tentatively made and should be reviewed after study of the same sands in adjacent areas.

OIL AND GAS FIELDS AND POOLS BY SANDS

In the following discussion, a pool is defined as a body of oil or gas or both occurring in a separate reservoir and under a single pressure system. A field is a group of pools related to the same geologic feature.

Venango First Sand

Clough Field

The most important sand in the Clough Field is the Knox Third Stray. For discussion of this sand refer to Knox Third Stray sand below. The Venango First sand is the youngest and also the least important producing sand in the quadrangle. It is, however, the most important oil sand in the Tidioute quadrangle immediately to the west. In the Sheffield quadrangle the First sand produces gas in the Clough Field in Clinger wells No. 40, 41, and 42, Warrant 5106, Howe Township. The sand was found at depths from 715 to 721 feet and has thicknesses of 15 to 19 feet. It is also productive in some of the Salmon Creek oil pool wells.

Based on the various drillers' logs, the Venango First is present in much of the quadrangle, but is usually fine-grained and possibly too tight to produce.

Knox Third Stray Sand

Clough Field

The largest and most important Knox Third Stray sand pool in the quadrangle is located in the Clough Field, which lies in Warrants 5103, 5106, 5107, and 5110 in the southwestern part of the quadrangle. It contains about 550 acres. A small productive area southeast of the northern part of the field, for convenience, is included in this pool.

The Knox Third Stray sand, frequently called "Clarion" by the drillers, is encountered at an average depth of about 890 feet. The sand averages about 18 feet thick with an oil pay of approximately four feet. Pebbles generally occur in the top of the sandstone with a finer sand below which is the oil pay. The interval from the base of the Pink Rock to the top of the Stray is 550 to 565 feet. In the northern part of the pool the sand produces small amounts of water. Wells in the southwestern part produce considerably more water. Most wells are drilled through the

Table 3 *Shallow oil and gas sands of the Sheffield quadrangle.*

Age of Sands		Name of Units		Average Interval to Base of Pink Rock (feet)	Approximate Thickness (feet)
Upper Devonian	Conewango	First sand zone	Venango First	800	40
			Red Valley	685	27
		Second sand zone	Venango Second	600	20
		Third sand zone	Knox Third Stray	550	12-20
			Knox Third	530	10-20
			Knox Fourth	505	12
			Knox Fifth	480	7
	Conneaut	Magee Hollow		410	32
		Pink Rock		350	350
		First Warren		0	15
		Second Warren		85	15-32
		Queen zone (Glade)		180	80
	Canadaway	Clarendon Stray		290	12-18
		Clarendon		325	18
		Upper Balltown		360	20
		Lower Balltown		390	8-20
		Cherry Grove		425	18
		Tiona		490	25
		Cooper Stray		565	20
		Cooper		600	24
		Klondike		665	10
		Deerlick		735	18
		Sartwell		1200	15-21

Knox Third sand below, which yields salt water, gas, and a little oil.

The first well in this pool was drilled in 1949; Well 33 produced the first oil from the pool. At present, spacing ranges from 350 to 1000 feet between wells. Initial productions range up to 30 barrels per day and settle at three barrels per day. An analysis[1] of Knox Third Stray oil from Clinger No. 34, Warrant 5106, Howe Township, showed the oil to be brownish-green in color with an A.P.I. gravity of 48.1°. At present there are 47 producing wells in the pool. Since the limits of this field have not been entirely determined, and wide well spacing exists, the pool should be extended and interdrilling would be feasible.

This Clough field is under successful gas drive. Three gas input wells are in operation, obtaining most of their gas from wells drilled to the Knox Third sand.

Slater Run Pool

The Slater Run gas pool is located in Howe Township in Warrants 3803 and 3802. The Knox Third Stray is the productive sand in this pool whose limits have been well outlined by dry holes. The greater portion of the area has been abandoned because production had declined beyond the economic limit. The pool contains about 318 acres.

The total thickness of the Knox Third Stray, which lies about 800 feet below the surface, as reported, ranges between 15 to 25 feet, averaging about 20. Present day well spacing is 600 to 700 feet. Initial production of these wells averaged about 60,000 cubic feet per day. Salt water is present in the bottom of the sand. A portion of the gas is piped several miles to the north and injected in a gas drive project. The balance of the gas is sold to the local gas company.

Salmon Creek Pool

The Salmon Creek pool is in northwestern Jenks Township in the south-central part of the quadrangle. The first well was drilled in this pool in 1906.

The Knox Third Stray sand in this pool lies at an average depth of 800 feet. It is a fine-grained to coarse-grained white sandstone with grains up to two-tenths inch in length. The thickness of the sand averages 12 feet. Approximately eight feet of the sand is considered "pay" sand. The top part of the sand is a hard cap rock with eight feet of coarse sand below and the remainder of the sand is dark and broken. Occasionally the pay sand is conglomeratic.

Initial production of some of the early wells was as high as 50 barrels per day with a large amount of gas. Production declined to an average one-eighth barrel per day of oil and twice as much water. At present the pool is watered out and the wells are standing. Present well spacing is about 350 feet. Early wells were shot with 20 to 60 quarts of nitroglycerin. An occasional well would encounter gas production in the Venango First sand. One such well had an initital production of over 200,000 cubic feet per day from this sand. Secondary recovery has never been tried in this pool, which contains about 123 acres.

[1]See appendix for complete analysis.

Other Knox Third Stray Sand Pools

Three other small Knox Third Stray sand pools are located in the southern part of the quadrangle in Warrants 3779, 3183, 3184, and 5104.

In 1912 the Duhring Development Company drilled a five-well oil pool in the Knox Third Stray sand in Warrant 3779. The light-colored oil was produced from the 12-foot thick sand at a depth of about 850 feet. This pool is now abandoned.

Three Knox Third Stray sand gas wells were drilled between 1938 and 1941 in Warrants 3183 and 3184. The sand in one well was 19 feet thick and had an initial open flow of 25,000 cubic feet per day.

In Warrant 5104 two wells are producing gas from the Knox Third Stray sand and are reported to be the best gas wells in the area.

The orientation of the various Knox Third Stray pools is rather erratic and ranges from east-west to northeast-southwest and northwest-southeast. Extending these pools, therefore, is a bit hazardous as the direction of possible pool extension is difficult to predict.

Knox Third Sand

Clough Field

In the Clough Field, Warrants 5103, 5106, 5109, and 5110, the Knox Third sand is separated from the Knox Third Stray sand above by a 6-foot break. The top of the Knox Third sand lies about 910 feet below the surface or about 530 feet above the Pink Rock. This sand is also called "Clarion" by the drillers. The Knox Third sand is about ten feet thick and is productive where coarse. Occasionally this sand produces oil but it is generally productive of gas which is used in repressuring. Some salt water is generally produced with the gas or oil. For further discussion of this field refer to the Knox Third Stray sand below.

Cooper Field

In Warrants 3192 and 3193 near the town of Hastings, the Knox Third is well developed and productive of oil and gas in the Cooper Field. The sand lies at a depth of 800 feet on the hills and 300 feet along Tionesta Creek. The sand thickness is between 30 and 40 feet, averaging 35 feet. In Warrant 3192 the Knox Third sand is operated under gas drive. Gas is being injected at a pressure of about 250 pounds per square inch at a volume of 25,000 cubic feet per day. The Knox Third which carries large amounts of water, responds very well to the gas injection.

The most important producing horizon in the Cooper Field is the Cooper sand. For discussion of this sand refer to the Cooper sand heading.

Hearts Content Pool

The Hearts Content pool is partly in the Tidioute quadrangle. The area in the Sheffield quadrangle comprises about 172 acres, located along the western edge of the quadrangle in Warrant 3064. The Knox Third sand is a coarse pebbly sandstone five to seven feet thick at a depth of about 600 feet. Most of the production in this (eastern) end of the pool is gas. Development took place in 1934 to 1936.

Other Knox Third Sand Pools

The Knox Third sand is oil and gas (chiefly gas) productive in small, widely-spaced areas through the central east-west third of the quadrangle. Depths to the sand vary from 724 to 936 feet. The thickness of the sand ranges from 7 to 17 feet with a pay of 4± feet. The sand contains salt water in some areas.

Gas production in the Knox Third has been unusually good in lots 705, 706, 719, and 720 where one well had an initial production of six million cubic feet of gas per day[1]. Other wells in the same area had initial capacities of one to two million cubic feet. This four well pool, drilled in 1943-44, is now completely abandoned.

Two wells in lots 317 and 328 are producing gas from the Knox Third. The initial production of well 915 was 56,000 cubic feet per day with a rock pressure of 24 pounds per square inch in 24 hours.

In Warrants 2735 and 2877 the Knox Third sand is well developed but is non-productive except in well 17 of Warrant 2877, which produces gas. Three other wells in the area had shows of gas. In this area the sand is about 30 feet thick and lies about 600 feet below the surface.

In Warrant 5282 three wells produced from the Knox Third sand. This sand is found at a depth of about 250 feet and is about 10 feet thick. Initial productions ranged up to seven barrels per day of oil and a considerable amount of salt-water. Some wells were pumped 24 hours a day to produce the fluid. This pool is abandoned.

Magee Hollow Sand

Cooper Field

The Magee Hollow sand produces gas only from four wells located in two areas south of Donaldson, Sheffield Township, in the Cooper field. The sand is found at depths ranging from 590 to 730 feet and has a thickness of 30 to 35 feet. No details on the lithologic character of the sand in the producing area are known. Its correlative, as found in the samples of South Penn Oil Company, No. 1, Warrant 2993, consists of light-gray very fine sandstone and medium-gray shale.

Second Warren Sand

The Second Warren produces gas in several small areas in Warrants 5104 and 5106, Howe Township, and Lots 357 and 368 near Barnes, Sheffield Township. In the former area depths to the producing sand vary from 1290 to 1556 feet and the sand thickness ranges from 12 to 52 feet. Initial production capacities were 24,000 to 36,000 cubic feet of gas per day. Depths to the sand in the area near Barnes are 1030 to 1036 feet. The thickness of the sands is not recorded in this area.

Queen Sand Zone

The Queen Sand zone is an unimportant producer of gas and oil in the quadrangle, although in the Tidioute quadrangle, immediately to the west, this zone ranks first as a gas producer. Production from the zone is found in two small areas

[1]Floyd Clinger, personal communication.

in the northern third of the quadrangle, one being in Lot 368, near Barnes, and the other is located in Warrant 3017 south of Hearts Content. Gas and a small amount of oil were found in Clinger No. 2, Warrant 3017, and an initial production of 10 to 20 thousand cubic feet of gas in Clinger No. 5, Warrant 3017. Depths to the sand in these two wells is 1390 and 1461 feet with sand thicknesses of 23 and 65 feet respectively. Such rapid changes in the sand content within short distances are characteristic of this erratic zone.

In some areas only the lower part of the Queen zone is developed and is called the Glade sand. One well is productive from the Glade in Grace Confer No. 1, Lot 368 near Barnes. The depth to the sand in this well is 1036 feet. No other Glade data are available on the Confer well. It is reported that several wells drilled in Lot 650, Cherry Grove Township, were Glade producers but no records are available on these wells.

Clarendon Stray Sand

The Clarendon Stray sand is gas productive in a few small areas in Lots 288, 317, 328, 329, and 357. The sand is found at depths ranging from 1100 to 1573 feet and has a thickness of 12 to 25 feet. No data are available on the lithology of the Clarendon Stray in the producing area. In well samples the Stray was found to be similar to the Clarendon, being white to light gray and fine to locally coarse grained.

The Clarendon Stray is almost always logged as Clarendon by the driller. This is particularly true if the Stray and the Clarendon are merged into one sand as they are in some areas. One of the best guides for distinguishing the two sandstones is the interval to the base of the Pink Rock. The interval to the top of the Stray is approximately 290 feet, while the interval to the top of the Clarendon is rather constant between 325 and 335 feet.

Clarendon Sand

Clarendon Pool

The Clarendon sand, of the Clarendon pool, is the most important producing horizon in the Sheffield and Warren quadrangles. The Clarendon pool was discovered January 13, 1878, by the Tolles well at Bugsbee Mills near Stoneham, Warren County, initial production 20 barrels per day. The sand and pool were named for the town of Clarendon which is situated in the center of the pool. This pool extends from several miles north of the town of Warren south and southeast to Lot 360, Sheffield Township, approximately two miles southwest of the town of Sheffield. The producing area covers approximately 40 square miles. A small part of this pool in the Warren quadrangle is productive from the Glade sand described above and there are several small areas of Cherry Grove sand production in both quadrangles. About 4295 acres of Clarendon pool lies in the Sheffield quadrangle.

The Clarendon is a white to light-gray fine and medium to locally coarse-grained sandstone often having at the top a hard cap or tight conglomeratic "shell" approximately one foot thick. Below this "shell" approximately 4 to 12 feet of oil pay is found in a medium- to coarse-grained white sandstone. The Clarendon varies from 8 to 50 feet in thickness in the producing areas and is found at depths ranging from 1000 to 1570 feet.

The Clarendon sand has not been known for unusually large wells, initial production rarely being more than 25 barrels per day. The spacing of wells in the pool is rather irregular, but on developed properties the wells are commonly 300

to 600 feet apart. The gas pressure in the pool is greatly depleted although several years ago it was said that closed in wells could develop pressures of 25 pounds per square inch in 24 hours.

It is common to shoot new wells with 80 to 100 pounds of nitroglycerin. After shooting, recently completed wells seldom exceed five barrels a day, production declining to about one and one-half barrels by the end of the first year. The average rate of current primary production in the Clarendon is about one-tenth barrel per day.

The quality of the oil from the Clarendon sand in the Clarendon pool is comparable to the best grade Pennsylvania crude and is in demand because of its desirable refining properties. The oil is amber in color, usually transparent, and has an A. P. I. gravity ranging from 46°to 48°. Clarendon oil analyses are given in the appendix (p.60).

Additional Clarendon production is from five wells in Warrants 2980 and 2993, Howe Township, producing gas from the sand.

Air, gas injection, and water flooding have been employed in secondary recovery of oil in the Clarendon pool. There has been little success with air and gas repressuring, but water flooding has increased the production in numerous wells. About 12 percent of the entire Clarendon pool is being water flooded. Only two secondary recovery projects were in operation at the time of this investigation. One of these projects was started in April 1933, using gas and air as the injection media followed later by water. At first lease gas was injected by day and air by night, at a discharge pressure of 400 to 450 pounds into one well of a trial five-spot pattern until the gas supply dwindled to an insufficient amount about January 1934. Water was then injected at pressures from 800 to 1200 pounds per square inch at an intake rate of 12 to 15 barrels of water a day until the Spring of 1942. The spacing in this project was 200 feet between input and producers. There was very little if any response while air and gas repressuring took place. About a month after initiating the water flood, three of the wells increased from one-eighth barrel of oil to one barrel per day and the fourth well increased to four barrels per day. Possibly the injection of gas prior to water injection was responsible for the quick response after water flooding was initiated. This project was expanded but the recovery of oil from the entire project was considered by the operators to have required a longer period of time than desirable.

Analyses of Clarendon core data from various wells are given below:

	Depth in Feet	Average Porosity	Average Permeability	Average Oil Saturation bbls/acre foot
(1)	1261.0 - 1268.5	15.2%	8.1 md.	352
(2)	1267.0 - 1294.0	12.7%	2.4 md.	246
(3)	1028.1 - 1059.0	12.2%	0.37 md.	155
(4)	1013.5 - 1024.0	13.3%	4.31 md.	595

(1)Grosh, (Groach), Pickett and Stone No. 24, Lot 284, Sheffield Township.
(2)South Penn Oil Company No. 29, Lot 242, Sheffield Township.
(3)Yerdon No. 1A, Lot 242, Sheffield Township.
(4)Mill Creek, Burlingame No. 11, Lot 204, Sheffield Township.

A summary description of general water flood operations in the Clarendon pool by Fettke (1950, pp. 438, 439) is quoted below.

"The 'five-spot' pattern has been used, with well spacings of from 233 to 285 feet between water-intake and producing wells. Pressures applied at the face of the sand in the intake wells have ranged from 850 psi to 1,300 psi. Both the upper and lower parts of the sand body are shot heavily. The packer in the input wells is set in the 'cap rock' and usually no pocket is drilled, as there have been instances where water has been lost in strata both above the 'cap rock' and below the oil sand. An input rate of 11 to 12 barrels per day per well is considered good, and 6 barrels is about the average in territory where the total recovery of oil per acres is 1,500 barrels. It is important to keep the water plant in continuous operation, and to treat the water carefully because of the low input rates. Input rates of one or two barrels per day per well do not result in successful floods.

"With a 233-foot spacing between water-input and producing wells— 1 oil well for each 2 1/2 acres — about two years elapse before any effects from the flood are noticeable. A peak of about two barrels per day per well is attained in about three years; and this rate is then maintained for a period of from 2 to 3 years, during which time the wells produce practically all oil, with little or no water. When water starts entering the oil wells, the oil production drops off rapidly. Normally, a total recovery of about 1,500 barrels of oil per acre is obtained over a period of from 6 to 7 years. On one project, covering 75 acres, the average recovery per acre was 1,800 barrels, and there have been a few single 'five-spot' units where the recovery has been as high as 5,000 barrels. The irregularity of the sand, both vertically and laterally, presents a difficult problem in conducting flooding operations in the Clarendon Pool."

Balltown Sand

As mentioned under subsurface stratigraphy discussion of the Balltown zone, the sand is divided into an upper and a lower member. The total thickness of the entire zone is approximately 50 feet. Unusual thicknesses (75 to 110') of the Balltown zone, reported by the drillers in the vicinity of Truemans and Hastings, Howe Township, probably represent not only the entire Balltown zone, but also a merging of the Balltown and Cherry Grove which is stratigraphically below the Balltown.

Balltown-Truemans Pool

The upper member is productive in the Balltown-Truemans pool in a long, narrow northeast-southwest trending belt extending from Warrants 5214 and 5268 in the southwestern part of the quadrangle toward Porkey. There are several outlying areas both northwest and southeast of this belt which also are productive from the upper member. Northeast of Porkey the upper member producing area abruptly widens toward the limits of the main pool in the southwestern part of Sheffield Township. East and northeast of these limits, the upper member is productive in various sized areas east and west of Henrys Mills and north of Barnes. There is some production in this field from the Knox Third and Cooper sands, which is described under their respective sand headings.

The Balltown-Truemans Pool was named from the two settlements in the area. Owing to the proximity of the first big wells to the settlement of Balltown the sand was thus named. The pool was discovered in 1877, but was not developed until 1882. By April 18, 1883, twenty wells had been completed — 6 producers, 5 with shows of oil and 9 dry holes. The production from the six wells on that date was 1060 barrels per day. By October 6, 1883, forty-nine producing wells had been

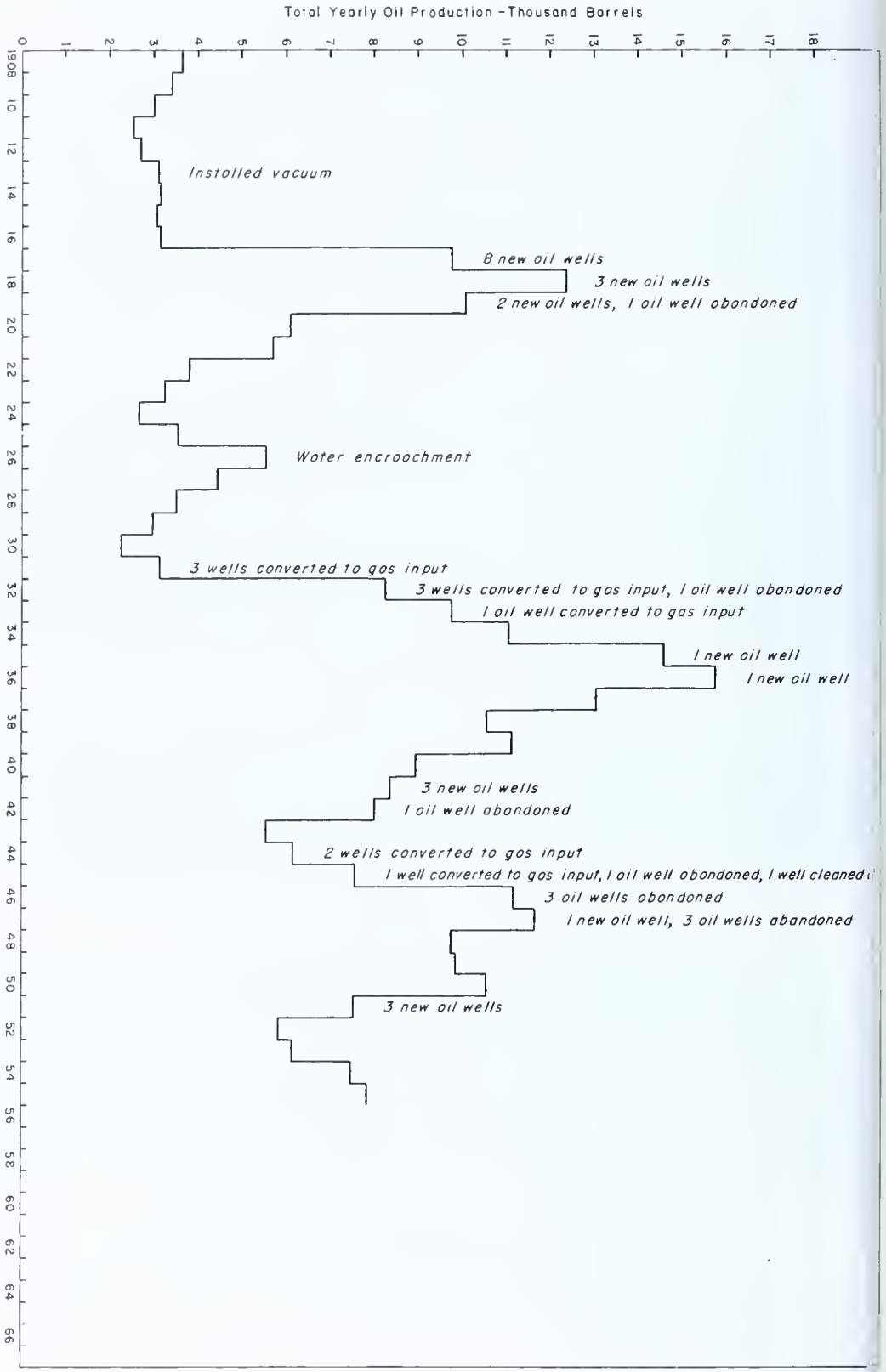


Figure 2. Balltown sand production curve of a lease in the Balltown-Truemons pool

drilled and were producing 6458 barrels per day. Although by May 25, 1884, eighty-eight wells had been drilled, the production had declined to 2124 barrels per day.

The upper member of the Balltown zone consists of 10 to 35 feet of a productive, fine- to coarse-grained, light-gray sandstone. Drilling depths to the upper member vary from 1150 to 1850 feet. The initial production of wells in this upper member ranged from a few barrels to 1000 barrels per day. At present an initial production of two barrels is considered good. Wells in some areas produce saltwater. The oil is light amber to straw-yellow in color and has an A. P. I. gravity of 44° to 46°.

The Balltown-Truemans pool consists of about 4100 acres of oil production or potential oil production and 2866 acres of gas production or potential gas production. Although all the wells produce gas along with their oil, the wells producing only gas occur in the extreme northern part of the pool as they do in most of the pools in the quadrangle. Production is here controlled by structure (migration updip) and stratigraphic trapping (migration to pinchout).

The production curve of a typical lease in this pool is shown on figure 2. Production figures prior to 1908 were not available. Prior to 1917, twenty-seven wells had been drilled and twenty-one wells abandoned. The property consists of 400 acres underlain by 20 feet of the upper member of the Balltown zone, with an estimated oil content of 250 barrels per acre-foot. This lease was operated under twenty points of vacuum from 1913 to 1931 when three wells were converted to gas injection. Since the vacuum pumps continued to be operated the project is a recycling project. From 1931 to 1955 the effects of injection wells, new wells, abandonments and cleanouts can be seen on the production curve. At the end of 1955, ten wells had been converted to injection wells with injection pressures of three to four pounds per square inch and had affected about 250 acres of the lease. Some of the oil was produced by wells outside the area affected by the gas injection. The wells are widely spaced and not "laid out" in a regular pattern. If they had been closely and properly spaced, it is likely that much more oil would have been recovered in a shorter period of time.

An analysis of pertinent Balltown core data is given below:

	Depth in Feet	Average Porosity	Average Permeability	Average Oil Saturation bbls/acre foot
(1)	1156.6 - 1174.0	11.76%	318.4 md.	132
(2)	1379.0 - 1402.0	18.1	760	361
(3)	1557.8 - 1641.4	10.67	---	149

(1)South Penn Oil Co. Core Well No. 1, Lot 3194, at Minister, Howe Township.
(2)South Penn Oil Co., No. 47, Lot 4792?, Howe Township.
(3)Forest Chemical Co., Herrick No. 36, Lot 2735, Sheffield Township.

Gas repressuring is being used for secondary recovery in the Balltown-Truemans pool with varying degrees of success. One such project is in operation in Warrant 3192, where near-by Knox Third and Cooper sand wells are the source of the gas. The pattern adopted is a "five-spot" and pressures of about 30 pounds per square inch are used. The production of the affected area has been estimated to show a 30 percent increase over the natural production. It is believed, however,

that wells over 800 feet from the intake well are not affected by the repressuring project. Some areas, as in Warrant 4821, have been subjected to a natural water flood. Although this pool was under vacuum for years, it is rarely in use today.

Another project injected gas into five input wells in the eastern part of Warrant 3192. The upper member of the Balltown took about 25,000 cubic feet of gas per day at 250 pounds per square inch. The results of the gas injection have been very encouraging.

A third project injected gas into the Balltown sand in Warrants 2735 and 2877. Two new inputs were drilled in a five-spot pattern. Gas was injected into one well for eight years and then into the two wells for three years, chiefly during the warmer six months of the year. Then gas was injected continuously into the two wells for four years. The injection pressure on the first well was thirty pounds per square inch, while the second well's injection pressure was 100 pounds per square inch. After seven years of injection the second well began to take an increase in volume and the pressure was finally reduced to 30 pounds per square inch. This property had fourteen points of vacuum on it when the second injection well was put into use. At the end of the four years of continuous injection the reservoir pressure ranged from three and one-half to five pounds per square inch. The oil production increased 30 percent.

Arner Pool

The Arner pool lies about two miles northwest of the town of Balltown. It is a long narrow pool trending northeast and southwest, and producing from the upper member of the Balltown. The pool is about two miles long and one-third mile wide, consisting of 100 acres of oil production and 135 acres of gas production. The gas wells had initial open flows of six to seven million cubic feet and an initial rock pressure of 750 pounds per square inch. Water flooding and repressuring with gas were tried in the oil productive part of the pool, but neither was successful. At present the northern gas end of the pool consisting of eleven gas wells is producing. The oil wells in the southern end of the pool are standing.

Blood Run Pool

The Blood Run pool is located about one mile south of Truemans. Production is from the upper member of the Balltown zone. The sand averages 20 feet in thickness and lies at a depth of about 1650 to 1700 feet. The 24 wells cover about 132 acres. Two of these wells are gas wells and a third is a gas input well.

Watson-Duhring Pool

This pool was discovered in 1890. The lower member of the Balltown zone is productive in the Watson-Duhring pool extending from the extreme southeast corner of the quadrangle, north and northwest to the vicinity of Henrys Mills. In the extreme northern part of the field, production is also found in the Cooper sand. The lower member of the Balltown is variously called the Second, Watson, or Duhring sand. The name of the pool was derived from the names of the properties on which some of the early wells were drilled.

The lower member of the Balltown zone is separated from the upper productive sand by about 10 to 30 feet of fine-grained sandstone and sandy shale. The lower productive sand consists of about 20 feet of fine- to coarse-grained sandstone. Drilling depths to the lower member vary from 1250 to 1850 feet. The initial pro-

duction of early wells in this pool ranged up to 100 barrels per day. Today an initial production of one barrel per day is considered good.

The lower member of the Balltown zone is productive in 4565 acres of the Watson-Duhring pool. The production curve of a typical lease in this pool is shown on figure 3. From 1895 to the end of 1955, thirty-one producing oil wells had been drilled and seventeen of these wells had been abandoned on this lease. By the end of 1901 all of the producing oil wells had been drilled. The decline was very rapid but production was revived somewhat when six wells were cleaned out. The decline was gradual until 1936, when the wells were affected by a natural water flood. The largest production occurred in 1897 when 16 oil wells produced 11,788 barrels for the year. By 1955 fourteen wells produced a total of only 274 barrels.

Some success has been experienced in an experimental water flood and gas drive project in this pool, but they have not been economical. On an unsuccessful project a pressure of 550 pounds per square inch could not force gas into the sand. Secondary recovery in this area does not look promising.

Other Balltown Pools

Both the upper and lower members of the Balltown zone are productive in small areas scattered over the quadrangle. Two of the larger areas are located north and west of Barnes in the northeastern section of the quadrangle. The two pools contain a total of 911 acres and are entirely productive of gas. The depth to the sand ranges from 1100 to 1600 feet. The sand averages nine feet thick. Initial production ranged from 2 to 35 thousand cubic feet per day. The Barnesville Gas Well as reported by Carll (1883, p. 24) was completed on February 10, 1879, with a large flow of gas from the Balltown zone. Three years later the heavy flow of gas still continued. Other small areas north and northwest of the Watson-Duhring field are productive of oil.

Cherry Grove Sand

Cherry Grove Pool

The Cherry Grove pool is a northeast-southwest trending area located in Cherry Grove township from which the sand and pool received their names. As stated in the subsurface discussion of the Cherry Grove sand, most of the pool was abandoned many years ago and very few well records are now available.

The "Mystery" well drilled on Lot 646 is credited with the discovery of the Cherry Grove pool. Four wells had been drilled in Cherry Grove township prior to the "Mystery" well, but two were very shallow, the third one drilled to about the horizon of the Clarendon sand, and the fourth one drilled through the horizon of the Cherry Grove sand, but failed to find oil. According to The Derrick's Handbook (1898), the "Mystery" well first struck oil on the tenth of March 1882, but operations were shut down until May 17 to give the operators time to lease additional land. The "Mystery" well flowed 200 barrels the first day after resuming operations and on the thirteenth of June it produced about 2000 barrels, which probably was its maximum yield.

The next two producing wells defined the field for at least two miles. This resulted in a very rapid development of an exceptionally productive oil field. By the latter part of August the pool was producing 40,000 barrels per day. Production from the "Mystery" well had fallen to less than one barrel a day by December 1882. As an example of the rapid decline in production, the Sardine Oil Company's well on

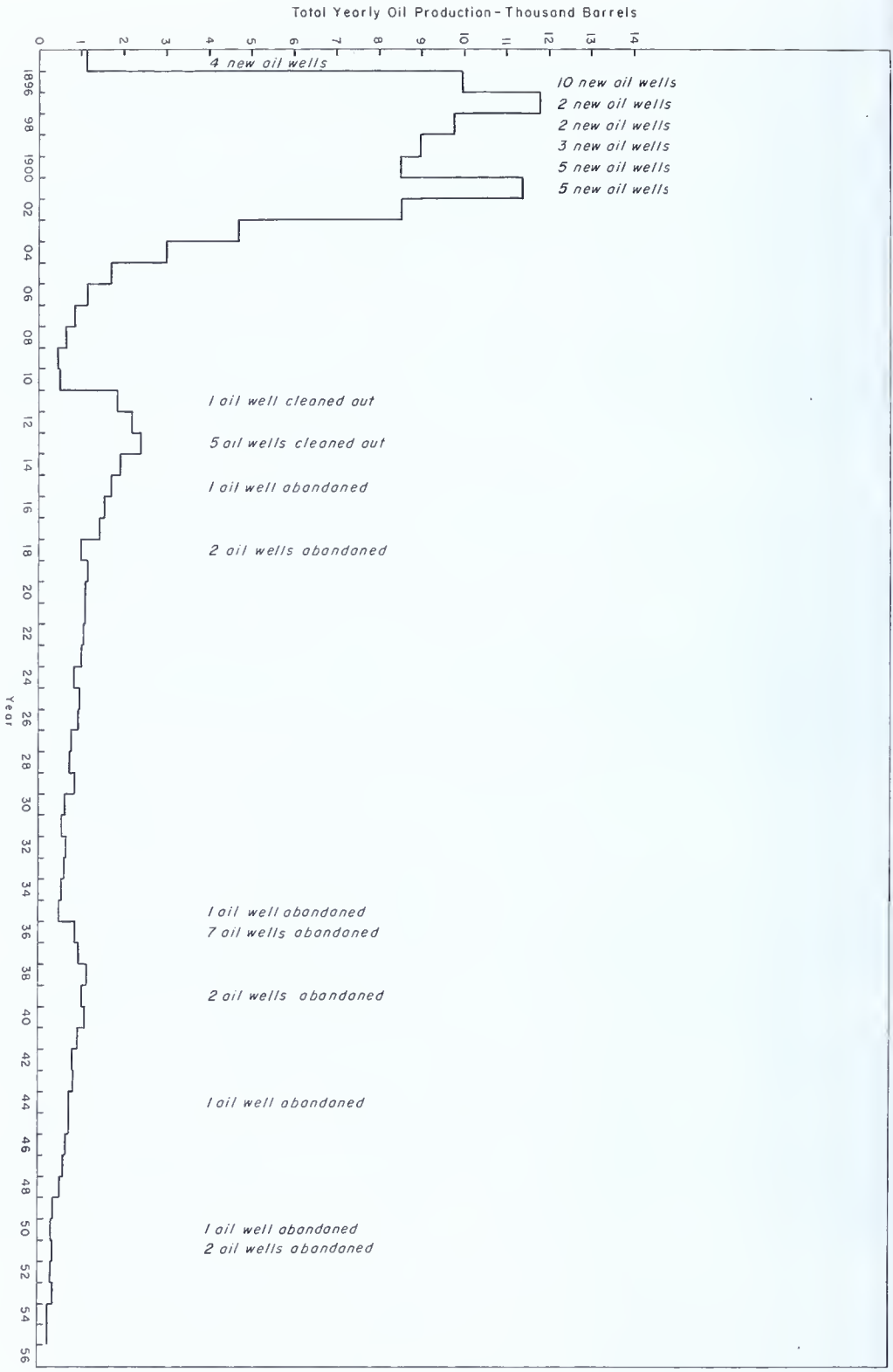


Figure 3. Balltown sand production curve of a lease in the Watson-Duhring pool

Lot 635 came in at 2000 barrels a day and in six days had declined to 274 barrels per day. On May 26, 1883, the production for the entire pool had declined to 2401 barrels per day from 319 producing wells. Seventy-four producers had been abandoned and 33 wells were dry, making a total of 426 wells drilled in the pool on the above date. The total production of the pool on this date was 2,733,864 barrels. By 1911 the pool was flooded with either fresh or connate water and practically exhausted. Today there are about 15 wells producing and 490 wells abandoned.

The Cherry Grove sand as seen in the samples of Booth Associates No. 1, a dry test drilled on Lot 660 along the southeast side of the pool, consists of six feet of fine-grained to pebbly sandstone below which is 15 feet of silty shale and fine-grained sandstone. Another cored well on Lot 635 drilled by the Cherry Grove Development Corporation, showed the Cherry Grove sand to consist of 13.2 feet of a well rounded coarse-grained sandstone with 1.4 feet of fine-grained very hard light gray sandstone at the bottom. This core was taken in a watered area of the pool, consequently the oil and water saturation values were not significant. A third cored well by R. B. McKinney Well No. 1 on the Wyckoff farm, Lot 608, Cherry Grove Township, encountered 21.1 feet of Cherry Grove sand. The upper 4.3 feet from 1760.7 to 1765.0 was a very coarse-grained well cemented sandstone. The bottom 16.8 feet was a very hard dark-gray sandy shale. This lower section did not show any oil when tested in the laboratory. Core data on the upper 4.3 feet is shown below:

Depth in Feet	Average Porosity	Average Permeability	Average Oil Saturation bbls/acre foot
1760.7 - 1765.0	17.3%	23.3 md.	228

These three wells give a good picture of the sand characteristics on a north and south line across the pool. A thick coarse sandstone is present in the middle of the pool and this coarse part thins toward the edges. The pool contains approximately 3770 acres of which 530 acres produced gas only.

The thickness of the Cherry Grove sand ranges from 10 to 25 feet with 4 to 13 feet of pay. Drilling depths range from 1080 to 1760 feet. The so-called "Reed and Brenneman" sand, logged in a few wells, and the Garfield and Gartland sands, are probably correlative with the Cherry Grove. The A.P.I. gravity of Cherry Grove oil obtained from a well in Lot 637 is rather high, being 50.6 degrees. (see appendix, p. 65, for a complete analysis). Wells in the southern part of the pool produce oil darker in color than wells in the northern part. From experience in other flooded Pennsylvania pools, it seems altogether possible that this pool might be dewatered and produce considerable oil.

An experimental gas repressuring secondary recovery project in the Cherry Grove sand has been tried on Lot 683. The setup consisted of one injection well and four producing wells arranged roughly in a five-spot pattern with 350 to 380 feet between producing wells with the injection well in the center. The intake well and two of the producers were new wells, while the other two wells of the pattern were old wells and were not cleaned out prior to the start of the experiment.

Lease gas from the Cherry Grove sand was injected continuously into 9 to 11 feet of pay sand for over a year. The quantity of gas injected was 6 to 18 MCF daily at an injection pressure of 680 pounds per square inch. The results of the experiment were considered unsatisfactory and no effect was noticed on any of the producing wells. No bypassing of gas occurred - there being no increase of gas

at any of the wells on the lease.

Tiona Sand

The Tiona sand as considered in this report is not to be confused with the sand of the same name in the vicinity of the town of Tiona. Apparently some driller mistook this sand for the productive horizon at Tiona which is actually the Clarendon sand.

Beaver Meadows Pool

The Beaver Meadow gas pool produces in an east-west trending area located in Warrants 3181, 3182, and in the southeastern corner of Warrant 3185. The pool contains about 287 acres.

The top of the Tiona sand occurs approximately 50 feet below the base of the Cherry Grove sand. The sand thickness varies from 18 to 44 feet and averages 30 feet at an average depth of 1900 feet. The top of the sand is covered with a hard cap rock below which occurs six feet of white coarse-grained "pay" sand. The rest of the sand is light gray fine-grained sandstone with some dark-gray shale. If the entire sand is dark in color there is no production. The initial production of early wells ranged from 4000 to 200,000 cubic feet per day. Out of the 25 producers drilled in the pool, only seven are producing at present. The seven wells produce a total of 25,000 cubic feet per day of gas and a very small amount of water. The produced gas is used in Marienville at the Marienville Glass Company's plant.

Cooper Stray and Cooper Sands

Cooper Pool

The Cooper Stray—Cooper Sand zone is productive in a northeast-southwest-trending bifurcated area extending from the vicinity of Hastings, Howe Township, into the neighboring Kane quadrangle. The Cooper producing trend is broken into a southeast oil belt of 5580 acres and a northwest gas belt of 4730 acres, by a large, mainly unproductive, area extending from the southwest corner of Sheffield township toward and northeast of Barnes. There are, in addition, several smaller productive areas in Lots 738, 739, 754, and 755, in Warrant 2980 and 5101, Howe Township, and in Warrants 3671 and 3672, Jenks Township. Depths to the sands vary from 1320 to approximately 2000 feet.

The Cooper Stray and Cooper sands are both productive although a very large majority of the production is from the Cooper. In most cases the two sands are not logged separately. This, together with the very erratic nature of the zone and the incompleteness of many drillers' logs, often makes it difficult or impossible to determine if a sand is Cooper Stray or Cooper.

The discovery well in this pool was the Shannon Well on the Cooper tract, completed in the latter part of 1882. The name of the sand and pool was derived from the tract name. Some of the Cooper wells drilled in the early days of the pool had productive capacities in excess of 1000 barrels of oil a day. Some very large Cooper gas wells were also drilled although their flow is not known. Five producing wells had been completed in the pool by the end of 1882. Some of these were large gushers. The field was developed rapidly during 1883. Torpedoes were used in the wells to try to maintain production. In spite of the torpedoes the production declined from a maximum of 5011 barrels per day from 75 producing wells on

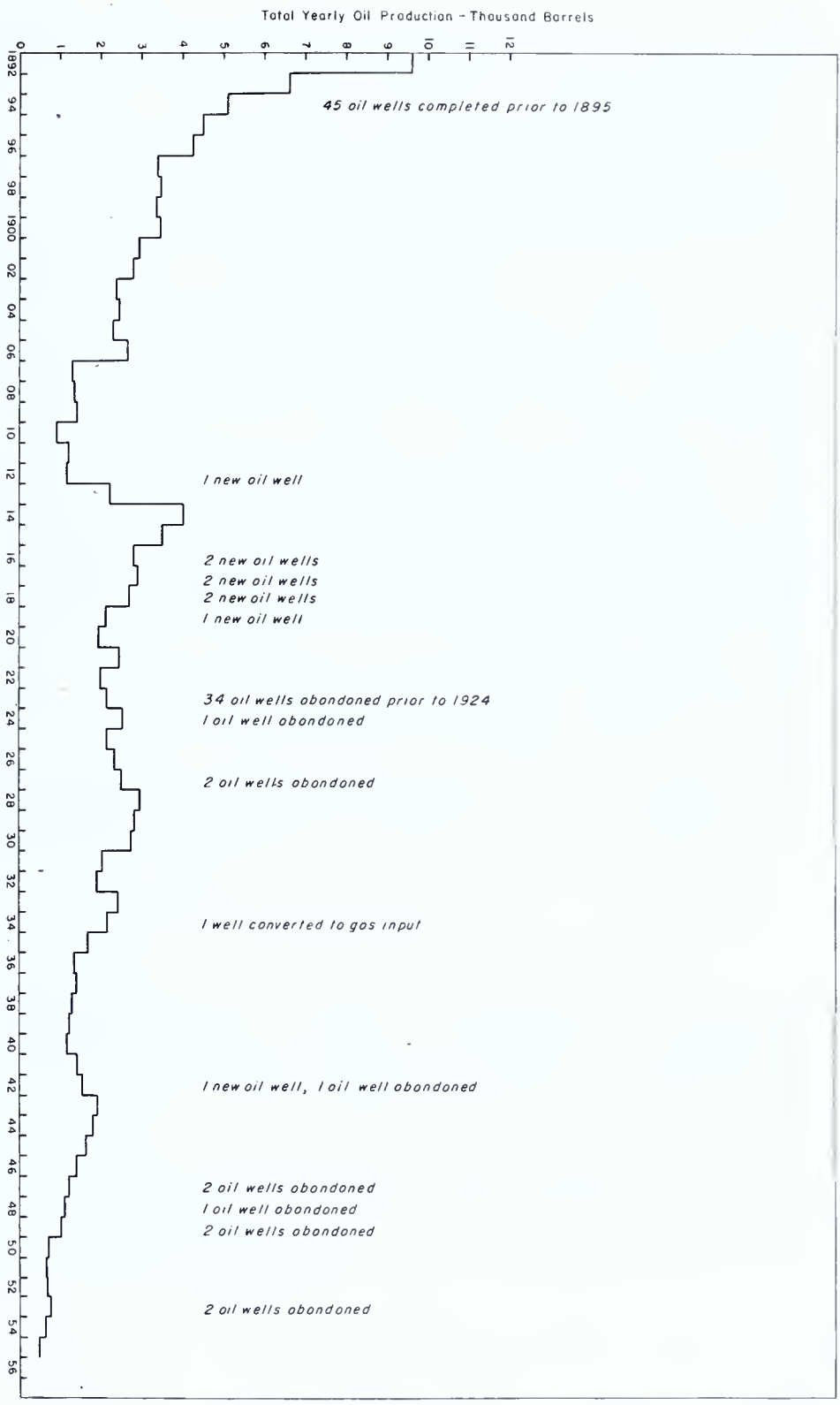


Figure 4. Cooper sand production curve of a lease in the Cooper pool

June 1, 1883, to 2782 barrels per day from 147 wells on January 8, 1884. Production again rose to a peak of 5010 barrels per day from 182 wells on March 23, 1884, and then started to decline. On May 25 two hundred and nineteen wells were producing 3698 barrels per day.

As mentioned in the subsurface discussion, the drillers used the terms "White Cooper" and "Red Cooper". The former refers to a light-gray to white sand, the latter to a reddish-brown sand. Except in small areas, there does not appear to be any uniformity in the distribution of the two sand colors. In some areas the red is found below, the white above, in other instances, the order is reversed. No samples are available in the Cooper producing areas, but some of the operators report that the red sand is widespread while the white has more of a shoestring character. Production characteristics and success of secondary recovery operations vary in the two sands. The white sand is coarser, more permeable, and has a greater initial production, although shorter life than the red sand. Operators report, too, that gas or air repressuring is successful in the white sand, but not in the red.

Both the Cooper Stray and Cooper have a pebbly cap rock one to two feet thick below which the coarse-grained to pebbly pay is found. The Cooper zone ranges from 10 to 50 feet in thickness, averaging 20 feet. The Cooper is generally more coarse than the Cooper Stray. The pay zone is often shot with 40 to 100 quarts of nitroglycerin. The presently-producing oil wells average about one-eighth barrel of oil per day. Figure 4 is a production curve of a typical lease in the Cooper field showing the affects of new wells, abandoned wells and injection wells on the oil production.

An analysis of Cooper core data from South Penn Oil Company, Cooper No. 62, Howe Township, is given below:

Depth in Feet	Average Porosity	Average Permeability	Average Oil Saturation bbls/acre foot
1898.5 - 1910.0	13%	0.24 md.	250
1920.3 - 1940.7	12.8	33.1	301

An experimental repressuring project was tried in the Cooper sand on the Forest Chemical Company tract. Beginning in 1938 one pressure well was maintained at an input pressure of 30 pounds per square inch. Bypassing developed after about a year of injection and the project was abandoned when the volume of produced gas approached the amount being injected. The injection of gas doubled the production of the surrounding wells prior to bypassing.

Much the same results were noticed in an experiment on Lot 438 where two new injection wells were completed in the Cooper sand. Gas was injected continuously at about 15 MCF per day at a well head pressure of 60 pounds per square inch. After eight months the injection pressure had increased to 90 pounds per square inch and bypassing was very bad. The experiment was abandoned. Prior to bypassing the oil production was doubled in the two oil wells nearest the input wells.

Two known water flooding experiments were tried in the Cooper sand, one intentional, the other accidental. The intentional flood was on Warrant 3193.

The flood was not carried on long enough to be conclusive.

The accidental flood was in Lot 397 where a well stood full of water for two or three years and was then plugged. A well about 250 feet from the water well showed an increase in production of about 60 barrels annually from the Cooper sand. Several wells were drilled later in Lot 397 and they were all good wells and have not come on to water. The well that had shown an increase in production was practically flooded out - producing six barrels of water to one barrel of oil per week ten years after the increase was first noticed.

Klondike Sand

Bull Hill Pool

The Klondike is productive of oil and gas in a narrow northeast-southwest belt extending from Lot 711, Cherry Grove Township to Lot 324, Sheffield Township. Northeast of Lot 324 there are three small isolated areas of Klondike production in Lots 280, 284, 285, 320, and 321. The Bull Hill pool was discovered about 1899. The developed acreage is approximately 398.

The sand is 8 to 15 feet thick and is found at depths ranging from 1902 to 2088 feet. Often a well developed gas cap is found above the oil. The sand is a light-brown fine-grained sandstone. The initial oil production has ranged from one to fifteen barrels per day. Secondary recovery has not been tried in the pool.

The Klondike is frequently called Cooper by the driller. From top to top the Cooper-Klondike interval is approximately 35 feet. In reference to this interval, it has been pointed out under the subsurface discussion that the top of the Cooper in the Bull Hill area is believed to be stratigraphically lower than top elsewhere. The lowered top is believed to represent a facies change, that is, the uppermost Cooper equivalent in the Klondike area is shale or sandy shale. The 35-foot interval, therefore, is abnormally thin compared with the interval in other parts of the quadrangle where 60 feet is about the average top to top interval from the Cooper to the Klondike.

Deerlick Sand

Deerlick Pool

This pool was discovered on January 7, 1890, when the J. M. Clapp No. 1 Well on Lot 169 came in at 350 barrels per day. This well was on Deerlick Brook, after which the pool was named. By January 27 there were eighteen wells drilling and the second well had been completed in the pool on Lot 170 at ten barrels per hour. On February 18, six wells produced 2642 barrels. On February 27, ten wells produced 3630 barrels, 2000 barrels coming from Horton, Crary and Company's No. 3, on Lot 170. On this date five dry holes had been drilled and two drilling wells abandoned. By March 9 twelve wells were producing 2000 barrels per day. The largest well in the field was reported as the Horton, Crary and Company's well on Lot 169, which produced 175 barrels per hour. The production of the pool declined rapidly as the following figures show:

March 28	3570 barrels per day
April 16	31 wells produced 2246 barrels
April 28	1000 barrels per day
July 25	36 wells produced 400 barrels

The best day's production for the pool was 6600 barrels.

This pool was later subjected to a water flood. During the flood some wells increased their production to 40 barrels per day. The sand is 15 to 22 feet thick and is found at depths ranging from 1580 to 2077 feet. A number of the wells were shot the same year they were drilled with 25 to 60 quarts of nitroglycerin. The water flood was in operation for three to four years until it got out of control. The pool is entirely flooded and a total of 76 wells have been abandoned. The water was introduced into the sand by pulling the casing in some wells and allowing the water to enter the sand. The area of this pool in the Sheffield quadrangle is 145 acres.

The Deerlick sand produced gas in Lot 167. The four-well pool is now abandoned. The initial production of the westernmost of the four wells is reported to have produced 500,000 cubic feet per day.

Deerlick sand structural data shows a very pronounced northwest dip in Lots 169, 196, and 197 contrary to the regional dip in this area, while Clarendon data in Lots 166 and 199 show general south dip. A synclinal area is therefore located northwest of the Deerlick field but there is insufficient data to locate the axial position of the structural low.

Sartwell Sand

Stratigraphically, the deepest production in the quadrangle is located in Warrants 3671 and 3672, Jenks Township. The producing sand is here called the Sartwell. It is often logged as "Elk" by the driller, although its correlation with Elk County producing sands has not been established.

The Sartwell sand is 10 to 32 feet thick and has an oil and gas pay ranging from 8 to 18 feet. The sand is found at depths of 2257 to 2573 feet. Initial production has ranged from one to three barrels of oil and 10,000 to 188,000 cubic feet of gas per day.

SECONDARY RECOVERY METHODS

Vacuum

Some of the oil pools in the Sheffield quadrangle were operated under vacuum. It is still used on a few leases today. Examination of figure 2, which is a production curve of a lease in the Balltown pool, shows a stimulative effect on the oil production from the use of vacuum. This effect only lasts a few years, and after that the wells produce no more than they would have had vacuum not been applied. The Balltown lease referred to above was gradually converted to pressure; vacuum was continued on the producing wells and gas was injected into input wells. This had a great deal more effect than the vacuum alone. The producing wells are finally operated at atmospheric pressure or higher after the pressure has taken effect. Other leases in the Sheffield quadrangle have been converted from vacuum to pressure.

Gas Drive

One Knox Third Stray and one Knox Third sand oil-producing area are operated under successful gas drive. Possibly the most outstanding gas drive projects are in the upper member of the Balltown sand. Some leases have had excep-

tional increases in production under gas drive. Other areas of production from this member should respond favorably. Although very little success has been obtained from gas drive in the lower Balltown member it is thought that successful projects might be operated in carefully selected areas of maximum sand thickness. Only one gas drive project has been tried in the Cherry Grove sand and the results were unsatisfactory. The Cherry Grove pool was flooded with either fresh or connate water by 1911. A similar situation existed in the Petroleum Center pool in the Titusville quadrangle. This pool was de-watered and operated successfully under recycling of the gas, and, since 1931 under air drive. It is believed that de-watering of the Cherry Grove pool will bring oil into pumping wells with the possibility that an air or gas drive would be of assistance. The oil-water ratio that can be expected is impossible to predict but as de-watering operations in less permeable sands are comparatively successful it is thought that considerable oil may be recovered by de-watering this pool. Gas drive so far in the Cooper sand has not been too encouraging. The two projects investigated had increases in oil production but by-passing soon developed and the projects were abandoned. In carefully selected areas and under closely controlled injection with selective plugging, gas drive should be successful.

Water Flooding

Successful water flooding in the northern part of the Clarendon pool in the Warren quadrangle has been in operation for a number of years. A few projects are being operated along the eastern edge of the Clarendon pool in the Sheffield quadrangle. Other areas in this quadrangle where the Clarendon sand is not irregular should be amenable to water flooding and economically successful. Water flooding in the Cooper pool has been tried on only an experimental basis and was not successful. An unintentional flood increased the production of oil from some nearby producing wells. Possibly an intensive flood might be economically successful.

FUTURE SHALLOW EXPLORATION

The northwestern, south-central, and southwestern parts of the Sheffield quadrangle offer extensive areas for exploration. Only a few wells have been drilled in these sections and in most cases no information is available as to the depth of drilling or what was encountered. An example of successful exploration is the Clough field in Warrants 5103, 5106, 5107, and 5110 discovered in 1949. It now contains 550 acres and the limits to the southwest and northeast have not been determined.

DEEP EXPLORATION

Four "deep" tests have been drilled in the quadrangle, one of which stopped in the Lower Devonian Oriskany sandstone and three bottomed in the Salina (Silurian). All four tests were dry.

C. W. Bramer, Kraer No. 21, drilled on Lot 328, Sheffield Township to a depth of 5288 feet, was abandoned in the Salina, with no shows. Salt was encountered at 4905 feet but its thickness is not known. No data were reported on the Oriskany sand.

Evjen and Harris, Dusenberry No. 1 was drilled in Warrant 3010, Watson Township and was abandoned at 5052 feet, after drilling into the Salina. Two thousand cubic feet of gas were encountered in the Oriskany sandstone which was found at 4476-4480 feet. One barrel of oil and five barrels of salt water were obtained from the Helderberg at 4532 feet, the oil and salt water were soon exhausted.

W. C. Wasson, E. Collins No. 1 was an Oriskany test drilled to 5349 feet in Warrant 3189, Howe Township. A show of distillate and salt water was found at 5202 to 5204 in the Oriskany.

Collins and Richard drilled their Collins No. 134 to the Salina in Warrant 5236, Kingsley Township. It was abandoned at 5252 feet. A show of gas was obtained from the Oriskany at 4461-4467, and gas pockets were found in the Middle Devonian at 4330-4380.

These four tests which have penetrated the Oriskany have not adequately tested this sand in the quadrangle. The Oriskany shows which have been found indicate not only some porosity and permeability, but also the presence of hydrocarbons. It remains only to find a suitable trap. The structure on the Oriskany as interpreted by Fettke (1954) shows a monotonous regional dip only. A trap would probably have to be of the stratigraphic type since faulting is not known to exist here. Detailed information such as might lead to the discovery of such a trap is lacking.

REFERENCES

Ashburner, C. A., (1880), *Geology of McKean County,* 2nd Pa. Geol. Survey, vol. R.

_____and Sheafer, A. W. (1885), *Geology of Elk, Forest and Cameron Counties,* 2nd Pa. Geol. Survey, vol. RR, pts. 1 and 2.

Butts, C. (1910), *Warren, Pa., N.Y.,* Folio, U. S. Geol. Survey Folio 172.

Carll, John F. (1880), *Geology of the Oil Regions of Warren, Venango, Clarion and Butler Counties,* 2nd Pa. Geol. Survey, vol. 13.

_____(1883), *Geological Report on Warren County and the Neighboring Oil Regions,* 2nd Pa. Geol. Survey, vol. 14.

Caster, K. E. (1934), *Stratigraphy and Paleontology of Northwestern Pennsylvania,* Bull. of Amer. Paleo., vol. 21, no. 71.

Cathcart, S. h., Sherrill, R. E., and Matteson, L. S. (1938), *Geology of the Oil and Gas Fields of the Tidioute Quadrangle.* Pa. Geol. Survey, 4th ser., PR 118.

Chadwick, G. H. (1924), *Stratigraphy of the Chemung in Western New York,* N. Y. State Mus., Bull. 251.

Chance, H. M. (1880), *Geology of Clarion County,* 2nd Pa. Geol. Survey, vol. V2

Dickey, Parke A. (1941), *Oil Geology of the Titusville Quadrangle, Pa.,* Pa. Geol. Survey, 4th ser., Bull. M 22.

_____, and Sherrill, R. E., Matteson, L. S. (1943), *Oil and Gas Geology of the Oil City Quadrangle, Pa.,* Pa. Geol. Survey, 4th ser., Bull. M 25.

Fettke, C. R. (1938), *Bradford Oil Field.* Pa. Geol. Survey, 4th ser., Bull. M 21.

_____, (1950), *Water Flooding in Pennsylvania,* Pa. Geol. Survey, 4th ser., Bull. M 33.

_____, (1950), *Summarized Record of Deep Wells in Pennsylvania,* Pa. Geol. Survey, 4th ser., Bull. M 31.

_____, (1954), *Structure Contour Maps of the Plateau Region of North-Central and Western Penna.,* Pa. Geol. Survey, 4th ser., Bull. G 27.

Glenn, L. C. (1903), *Devonic and Carbonic Formations of Southwestern New York,* N. Y. St. Mus. Bull. 69.

Matteson, L. S. (1945), *Undrilled Areas of the Sheffield Quadrangle, Pa.,* Pa. Geol. Survey, 4th ser.

Sherrill, R. E., and Matteson, L. S. (1941), *Oil and Gas Geology of the Franklin Quadrangle. Pa.,* Pa. Geol. Survey, 4th ser., Bull. M 24.

(1898), *The Derrick's Hand-Book of Petroleum,* Derrick Publishing Co., Oil City, Pa.

APPENDIX A

WELL SAMPLE RECORD

South Penn Oil Company

Warrant 2993 No. 1

Forest County, Howe Township, two miles northeast of Deadman Corners, Sheffield Quadrangle, 800 feet south of 41°35', 50 feet west of 79°05', elevation 1764 feet.

Description by A. I. Ingham

Thickness Feet	Description of Strata	Depth in Feet
	PENNSYLVANIAN SYSTEM, 91 feet	
31	No samples	0 - 31
9	Sandstone, medium- to coarse-grained, white and yellow stained, angular to subangular	31 - 40
51	Similar to above but with sandstone fragments up to one-half inch; Base of Olean	40 - 91
	MISSISSIPPIAN SYSTEM, 360 feet	
	Patton (?), 10 feet	
10	Sandstone, fine- to coarse-grained; some light-gray, rarely red, silty shale.	91 - 101
	Shenango-Cuyahoga, 274 feet	
21	Sandstone, very fine-grained; little light-gray shale and a small amount of siderite; rare coal at 115-122	101 - 122
14	Shale, medium-gray, silty; light greenish-gray, sandy silt; rare coarse-grained quartz	122 - 136
27	Sandstone, very fine-grained, light-gray and greenish-gray, with some silt as in 122-136 and medium-gray, silty shale. Rare rounded and frosted coarse-grained quartz 156-163.	136 - 163
15	Sandstone, as in 136-163; very rare silt and shale as in 136-163	163 - 178
16	Sandstone, very fine-grained with rare rounded and frosted coarse grains; light-gray and greenish-gray and some dark-gray shale. Some sandstone at 186-194 has a distinct green color	178 - 194

Thickness Feet	Description of Strata	Depth in Feet
22	Shale; some very fine-grained sandstone, both as in 178-194	194 - 216
5	Sandstone, rare shale, both as in 194-216	216 - 221
5	Same as in 194-216 but sandstone and shale light brown in color. Contains rare coarse-grained quartz	221 - 226
5	Sandstone, very fine-grained, rare coarse-grained, light-gray; some medium gray shale	226 - 231
19	Shale,medium-gray, silty; some very fine-grained sandstone	231 - 250
10	Shale, as in 231-250, with silt, medium-gray; rare very fine- to coarse-grained sandstone	250 - 260
5	Sandstone, very fine-grained, dark greenish-gray; some dark-gray shale	260 - 265
47	Shale, dark-gray; light-gray siltstone and very fine grained light-gray sandstone. Rare coarse-grained quartz 290-312	265 - 312
5	Sandstone, fine-grained to coarse-grained to 3 mm, some coarse grains rounded and frosted; rare grayish-brown, siltstone, calcareous in part	312 - 317
6	Similar to 312-317 with rare dark-gray shale, fewer coarse grains	317 - 323
16	Sandstone and rare shale, both as in 317-323; some sandstone calcareous	323 - 339
6	Sandstone and shale, both as in 323-339	339 - 345
24	Sandstone, predominantly fine-grained with only rare coarse-grained quartz as in 312-345; dark-gray silty shale	345 - 369
6	Sandstone, fine-grained to rarely coarse-grained, light-gray and milky, in part calcareous; light-gray siltstone and dark-gray shale	369 - 375
	Knapp, 76 feet	
6	Similar to 369-375 but less silt; coarse-grained (to 2 mm) yellow- and orange-stained and milky quartz. Upper Knapp 375-404	375 - 381
6	Similar to 375-381 but predominantly sandstone	381 - 387

Thickness Feet	Description of Strata	Depth in Feet
6	Same as 381-387 but larger pebbles to 7 mm, well rounded, ovoid	387 - 393
5	Sandstone, commonly coarse, rarer fine-grained; some dark-gray, almost black shales	393 - 398
6	Sandstone, fine- to coarse-grained, light-gray to white; dark-gray shale	398 - 404
18	Shale, dark-gray, silty	404 - 422
7	Shale, as above; some fine-grained, light-gray sandstone. Middle Knapp	422 - 429
12	Shale, as in 422-429, no sandstone	429 - 441
10	Sandstone, fine- to coarse-grained, light-gray, rose, yellow stained, in part calcareous; medium-gray shale. Lower Knapp	441 - 451
	DEVONIAN SYSTEM, 1802 feet	
	Conewango Group, 451 feet	
	Riceville (Oswayo) formation, 149 feet	
15	Shale, medium-gray	451 - 466
14	Shale, medium-gray; light-gray siltstone	466 - 480
28	Shale, medium-gray	480 - 508
42	Shale, medium-gray; fine-grained, light-gray and greenish-gray, partly calcareous sandstone	508 - 550
50	Sandstone, very fine-grained, light-gray and greenish-gray, in part calcareous; dark-gray silty shale. Thin coal laminae at 550-560 and possible fossil fragment at 579-589	550 - 600
	Cattaraugus formation, 326 feet	
34	Sandstone, fine-grained, light-gray, dark-green, and pink- to brick-red (no red or pink 620-627); medium- to dark-gray shale. Venango First sand	600 - 634
7	Sandstone, very fine-grained, light-gray, loose, well sorted; rare dark-gray shale	634 - 641
14	Sandstone, fine-grained, light-greenish gray; dark-gray shale	641 - 655

Thickness Feet	Description of Strata	Depth in Feet
36	Sandstone, fine-grained, light-gray; medium-gray and brick-red shale and siltstone	655 - 691
9	Similar to 609-691 but increasing amount of siltstone and shale and rarer red	691 - 700
14	Shale, dark-gray; very fine-grained light-gray sandstone	700 - 714
76	Sandstone, fine-grained, light-gray, and greenish-gray; brick-red, green and medium-gray siltstone and silty shale. Abundant red 725-772. The top of this unit, 714 feet, is probably correlative with the top of red in the Oil City quadrangle. Venango Second sand at 772-790	714 - 790
27	Similar to 714-790 but sandstone more abundant. Common red color	790 - 817
17	Sandstone, fine- to coarse-grained, light-gray, chiefly angular with a few rounded and frosted grains; dark-gray and brick-red (rare red) silty shale. Knox Third Stray sand	817 - 834
9	Shale, dark-gray, silty	834 - 843
2	Sandstone, fine-grained, ashy-gray, in part calcareous; dark-gray shale. Knox Third sand	843 - 845
7	Shale, dark-gray	845 - 852
11	Shale, dark-gray; light-gray, rarely purplish-gray silt; rare very fine-grained, occasionally coarse-grained sandstone	852 - 863
32	Shale, dark-gray, some purplish-gray at 871-886	863 - 895
7	Sandstone, very fine-grained, light-gray and dark-gray shale. One fossil fragment	895 - 902
	Tanner's Hill member, 33 feet	
7	Sandstone, fine-grained, light-gray; light-gray and brick-red silty shale	902 - 909
26	Siltstone and shale, medium-gray and reddish-purple; some sandstone as in 902-909	909 - 935

Thickness Feet	Description of Strata	Depth in Feet
	Conneaut Group, 680 feet	
45	Shale, dark-gray with rare very fine-grained sandstone (Magee Hollow?) at 968-980	935 - 980
42	Shale, dark-gray, common fossils 980-994, fewer fossils 994-1022	980 - 1022
	Pink Rock, 355 feet	
65	Shale, dark-gray and purplish-gray; rare fine-grained sandstone 1039-1087. Common fossils	1022 - 1087
41	Shale, dark-gray and purplish-gray; light-greenish-gray siltstone. Rare to moderately fossiliferous	1087 - 1128
67	Shale and siltstone as in 1087-1128; light greenish-gray fine to rarely coarse-grained sandstone. Rare to moderately fossiliferous	1128 - 1195
19	Shale, light-gray and purplish-gray; rare light greenish-gray siltstone. Common fossils	1195 - 1214
26	Shales, as in 1195-1214. Common fossils	1214 - 1240
43	Shale, as in 1214-1240; some light greenish-gray siltstone. Rare fossils	1240 - 1283
63	Same as 1240-1283 with increasing amounts of siltstone. Rare fossils	1283 - 1346
31	Sandstone, very fine-grained, light greenish-gray; purplish-gray shale. Rare to moderately fossiliferous. Base of Pink Rock, 1377	1346 - 1377
9	Shale, medium-gray with sandstone as in 1346-1377	1377 - 1386
9	Shale, medium-gray; light greenish-gray siltstone. One fossil fragment	1386 - 1395
49	Shale, medium-gray; some fine-grained, rarely coarse-grained light-gray sandstone; sandstone calcareous in part. Rare fossils 1395-1407	1395 - 1444
20	Sandstone, fine-grained, light-gray, in part calcareous with rare medium-gray shale	1444 - 1464
3	Sandstone, very fine-grained, well sorted, loose	1464 - 1467
35	Sandstone, fine-grained, light-gray; some medium-gray shale	1467 - 1502

Thickness Feet	Description of Strata	Depth in Feet
27	Shale, medium-gray; rare fine-grained, light-gray sandstone	1502 - 1529
8	Same as 1502-1529 but approximately one-half sandstone	1529 - 1537
17	Shale, medium-gray and grayish-brown	1537 - 1554
14	Shale, as in 1537-1554 with some light-gray siltstone; rare fossils 1562-1568	1554 - 1568
9	Shale, as in 1537-1554 with light greenish-gray fine-grained sandstone	1568 - 1577
19	Shale, medium-gray, and light-gray siltstone	1577 - 1596
19	Sandstone, fine- to coarse-grained, light greenish-gray, sub-angular, in part calcareous; medium-gray shale; light-greenish-gray siltstone. Rare fossils. Glade sand	1596 - 1615
	Canadaway Group, 638 feet	
57	Shale, medium-gray; greenish-gray siltstone. One fragment purplish-gray shale 1615-1625	1615 - 1672
15	Shale, medium-gray; medium-gray siltstone; very fine-grained, light-gray sand	1672 - 1687
15	Sandstone, very fine- to rare coarse-grained, clear, white; medium-gray and brownish-gray shale. Clarendon sand	1687 - 1702
33	Similar to 1687-1702 but predominantly shale. No coarse grains 1718-1735	1702 - 1735
41	Sandstone, fine-grained to moderate amount coarse grains; medium-gray shale; rare purplish-gray siltstone. Balltown sand	1735 - 1776
36	Similar to 1735-1776 but no coarse-grained sandstone. Some brick-red and purplish-gray siltstone 1785-1812	1776 - 1812
27	Sandstone, fine-grained to rarely coarse-grained, light-gray and greenish-gray; sandy, medium-gray shale. Cherry Grove sand	1812 - 1839
44	Shale, medium-gray	1839 - 1883
20	Shale, as in 1839-1883 with fine-grained light-gray sandstone	1883 - 1903

Thickness Feet	Description of Strata	Depth in Feet
17	Shale, medium-gray and grayish-brown, rare purplish-gray; some light-gray siltstone	1903 - 1920
18	Sandstone, very fine to fine-grained; light-gray; medium-gray shale. Rare fossils 1929-1938. Cooper Stray sand	1920 - 1938
9	Siltstone, light-gray, sandy; medium-gray shale; rare very fine-grained sandstone	1938 - 1947
7	Sandstone, very fine- to fine-grained, with rare coarse grains, light gray and chocolate brown; siltstone and shale as in 1938-1947. Rare fossils	1947 - 1954
18	Similar to 1947-1954 but increasing amounts of sandstone	1954 - 1972
38	Sandstone, very fine- to coarse-grained, light chocolate-brown and dirty medium-gray; coarse grains sub-round to round, more angular 1982-2010, some frosted. Rarer brown color and rare light-gray shale 1994-2002. Cooper sand	1972 - 2010
6	Shale, medium-gray	2010 - 2016
62	Shale, medium-gray and dark-brown	2016 - 2078
28	Same as in 2016-2078 with rare fine-grained light-gray sand	2078 - 2106
24	Sandstone, light-gray, fine-grained; rare medium-gray shale	2106 - 2130
26	Shale, medium-gray; medium-gray sandy siltstone. Common fossils at 2148-2156	2130 - 2156
9	Sandstone, very fine-grained, light-gray; medium-gray shale	2156 - 2165
9	Shale, medium-gray; light-gray sandy siltstone	2165 - 2174
45	Siltstone, light-gray; medium-gray shale; rare very fine-grained sandstone. Common fossils 2202-2219	2174 - 2219
34	Same as 2174-2219 but no sand. Common fossil fragments	2219 - 2253
	TOTAL DEPTH	2253

APPENDIX B

CRUDE OIL ANALYSIS

REPORT OF CRUDE PETROLEUM ANALYSIS*

Bureau of Mines Bartlesville Laboratory
Sample 51003

IDENTIFICATION

Clough field	Clinger Oil and Gas Co.	Pennsylvania
Knox Third Stray Upper Devonian	Clouth No. 34	Forest County, Howe Township
864-902 feet	Lot 5106	Sheffield Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.788 A.P.I. gravity, 48.1° Pour point, °F. below 5
Sulfur, percent, less than 0.1 Color, brownish green
Saybolt Universal viscosity at 100° F., 36 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 737 mm. Hg
First drop, 28° C. (82° F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp. Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point, °C.	S.U. Visc., 100°F.	Cloud test °F.
1	50	122	3.9	3.9	0.634	91.7	-	-		
2	75	167	4.4	8.3	.658	83.6	1.8	-		
3	100	212	7.1	15.4	.697	71.5	11	61.4		
4	125	257	8.1	23.5	.722	64.5	13	60.0		
5	150	302	7.1	30.6	.741	59.5	15	61.6		
6	175	347	6.3	36.9	.755	55.9	14	64.8		
7	200	392	5.9	42.8	.768	52.7	14	68.4		
8	225	437	5.1	47.9	.781	49.7	15	73.2		
9	250	482	5.3	53.2	.792	47.2	15	77.8		
10	275	527	5.7	58.9	.804	44.5	16	82.2		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.1	62.0	0.814	42.3	17	85.4	40	25
12	225	437	5.2	67.2	.828	39.4	19	89.2	44	40
13	250	482	4.5	71.7	.837	37.6	20		53	60
14	275	527	4.5	76.2	.848	35.4	22		68	70
15	300	572	4.2	80.4	.854	34.2	22		105	80
Residuum			18.3	98.7	.896	26.4				

Carbon residue of residuum, 3.6 percent; carbon residue of crude, 0.8 percent.

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	15.4	0.670	79.7	
Total gasoline and naphtha	42.8	0.718	65.6	
Kerosene distillate	16.1	.793	46.9	
Gas oil	9.3	.822	40.6	
Nonviscous lubricating distillate	9.6	.835-.853	38.0-34.4	50-100
Medium lubricating distillate	2.6	.853-.857	34.4-33.6	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	18.3	.896	26.4	
Distillation loss	1.3			

*Published by permission of Director U. S. Bureau of Mines.

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51004

IDENTIFICATION

Clarendon field	Warren Group	Pennsylvania
Clarendon sand, Upper Devonian	No. 4	Warren County, Mead Tw
1,237-1,250 feet	Lot 205	Sheffield Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.791 A.P.I. gravity, 47.4° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N.P.A. No. 3
Saybolt Universal viscosity at 100°F., 37 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 737 mm. Hg
First drop, 27°C. (81°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp. Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point, °C.	S.U. Visc., 100°F.	Cloud test °F.
1	50	122	3.5	3.5	0.633	92.0	-	-		
2	75	167	3.5	7.0	.655	84.5	0.4	62.2		
3	100	212	6.3	13.3	.701	70.4	12	59.4		
4	125	257	8.1	21.4	.730	62.3	17	56.4		
5	150	302	6.0	27.4	.749	57.4	18	55.4		
6	175	347	6.1	33.5	.764	53.7	19	58.8		
7	200	392	5.1	38.6	.775	51.1	18	64.8		
8	225	437	5.1	43.7	.782	49.5	15	40.4		
9	250	482	5.4	49.1	.798	45.8	18	75.8		
10	275	527	6.0	55.1	.809	43.4	18	78.8		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	1.1	56.2	0.821	40.9	20	-	39	20
12	225	437	6.4	62.6	.830	39.0	20	86.8	42	30
13	250	482	4.9	67.5	.840	37.0	22		51	50
14	275	527	4.8	72.3	.850	35.0	23		68	70
15	300	572	5.4	77.7	.858	33.4	24		105	85
Residuum			18.3	96.0	.892	27.1				

Carbon residue of residuum, 1.5 percent; carbon residue of crude, 0.3 percent

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	13.3	0.671	79.4	
Total gasoline and naphtha	38.6	0.724	63.9	
Kerosene distillate	16.5	.797	46.0	
Gas oil	9.4	.830	39.0	
Nonviscous lubricating distillate	9.9	.839-.858	37.2-33.4	50-100
Medium lubricating distillate	3.3	.858-.864	33.4-32.3	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	18.3	.892	27.1	
Distillation loss	4.0			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS

Bureau of Mines Bartlesville Laboratory
Sample 51005

IDENTIFICATION

Clarendon field	South Penn Oil Co.	Pennsylvania
Clarendon sand, Upper Devonian	No..38	Warren County, Mead Twp.
981-1,006 feet	Lot 106	Warren Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.785 A.P.I. gravity, 48.8° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N.P.A. No. 2 1/2
Saybolt Universal visosity at 100°F., 36 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 737 mm. Hg
First drop, 27°C. (81°F.)

Fraction No.	Cut at °C.	Cut at °F	Percent	Sum, Percent	Sp.Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point, °C.	S.U. Visc., 100°F.	Cloud test, °F.
1	50	122	5.7	5.7	0.627	94.2	-	-		
2	75	167	3.9	9.6	.659	83.2	2.3	62.6		
3	100	212	5.7	15.3	.703	69.8	13	58.2		
4	125	257	7.5	22.8	.730	62.3	17	56.0		
5	150	302	5.9	28.7	.749	57.4	18	56.4		
6	175	347	6.0	34.7	.763	54.0	18	59.0		
7	200	392	5.4	40.1	.774	51.3	17	65.0		
8	225	437	5.1	45.2	.785	48.8	17	65.0		
9	250	482	5.3	50.5	.797	46.0	17	75.0		
10	275	527	6.2	56.7	.810	43.2	19	79.0		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.0	59.7	0.823	40.4	21	84.4	42	20
12	225	437	5.1	64.8	.832	38.6	21	88.2	45	35
13	250	482	4.7	69.5	.841	36.8	22		55	55
14	275	527	4.1	73.6	.849	35.2	23		73	70
15	300	572	4.7	78.3	.858	33.4	24		115	80
Residuum			17.2	95.5	.890	27.5				

Carbon residue of residuum, 0.9 percent; carbon residue of crude, 0.2 percent

APPROXIMATE SUMMARY

	Percent	Sp.Gr.	°A.P.I.	Viscosity
Light gasoline	15.3	0.663	81.9	
Total gasoline and naphtha	40.1	0.718	65.6	
Kerosene distillate	16.6	.798	45.8	
Gas oil	8.0	.828	39.4	
Nonviscous lubricating distillate	9.7	.836-.855	37.8-34.0	50-100
Medium lubricating distillate	3.9	.855-.863	34.0-32.5	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	17.2	.890	27.5	
Distillation loss	4.5			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51006

IDENTIFICATION

Clarendon field	Seavy and Sharp	Pennsylvania
Clarendon sand, Upper Devonian	White No. 20	Warren County, Mead Twp.
992-1,016 feet	Lot 498	Warren Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.794 A.P.I. gravity, 46.7° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N.P.A. No. 3
Saybolt Universal viscosity at 100°F., 37 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 741 mm. Hg
First drop, 28°C. (82°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp.Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point, °C.	S.U. Visc., 100°F.	Cloud test, °F.
1	50	122	3.1	3.1	0.636	91.0	-	-		
2	75	167	3.5	6.6	.657	83.9	1.3	62.4		
3	100	212	5.7	12.3	.703	69.8	13	58.2		
4	125	257	7.1	19.4	.730	62.3	17	55.8		
5	150	302	6.1	25.5	.749	57.4	18	55.8		
6	175	347	6.1	31.6	.764	53.7	19	59.0		
7	200	392	5.0	36.6	.775	51.1	18	64.0		
8	225	437	5.0	41.6	.784	49.0	16	69.8		
9	250	482	5.4	47.0	.797	46.0	17	74.0		
10	275	527	6.1	53.1	.808	43.6	18	79.0		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	2.7	55.8	0.822	40.6	20	83.2	42	15
12	225	437	5.7	61.5	.831	38.8	21	86.0	44	35
13	250	482	4.7	66.2	.840	37.0	22		52	50
14	275	527	4.8	71.0	.848	35.4	22		68	70
15	300	572	4.8	75.8	.858	33.4	24		110	80
Residuum			19.8	95.6	.888	27.9				

Carbon residue of residuum, 0.9 percent; carbon residue of crude, 0.2 percent

APPROXIMATE SUMMARY

	Percent	Sp.Gr.	°A.P.I.	Viscosity
Light gasoline	12.3	0.673	78.8	
Total gasoline and naphtha	36.6	0.726	63.4	
Kerosene distillate	16.5	.797	46.0	
Gas oil	9.4	.827	39.6	
Nonviscous lubricating distillate	9.8	.837-.855	37.6-34.0	50-100
Medium lubricating distillate	3.5	.855-.863	34.0-32.5	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	19.8	.888	27.9	
Distillation loss	4.4			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51007

IDENTIFICATION

Mayburg field	Clinger Oil and Gas Co.	Pennsylvania
Balltown sand, Upper Devonian	No. 152	Forest County, Howe Twp.
1,596-1,618 feet	Lot 5236	Sheffield Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.798 A.P.I. gravity, 45.8° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N.P.A. No. 4 1/2
Saybolt Universal viscosity at 100° F., 38 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 747 mm. Hg
First drop, 27° C. (81°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp. Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point, °C.	S.U. Visc., 100°F.	Cloud test °F.
1	50	122	2.6	2.6	0.634	91.7		-		
2	75	167	3.9	6.5	.662	82.2	3.7	60.8		
3	100	212	5.8	12.3	.699	70.9	11	59.6		
4	125	257	8.0	20.3	.727	63.1	16	57.0		
5	150	302	6.3	26.6	.747	57.9	18	67.4		
6	175	347	6.1	32.7	.761	54.4	17	60.0		
7	200	392	5.5	38.2	.772	51.8	16	64.8		
8	225	437	4.9	43.1	.784	49.0	16	70.0		
9	250	482	5.7	48.8	.796	46.3	17	74.8		
10	275	527	6.2	55.0	.807	43.8	17	79.6		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.3	58.3	0.821	40.9	20	83.0	38	15
12	225	437	5.9	64.2	.831	38.8	21	87.8	44	35
13	250	482	5.6	69.8	.840	37.0	22		52	50
14	275	527	4.7	74.5	.848	35.2	22		71	70
15	300	572	4.9	79.4	.855	34.0	23		105	80
Residuum			19.4	98.8	.891	27.3				

Carbon residue of residuum, 1.2 percent; carbon residue of crude, 0.3 percent

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	12.3	0.674	78.4	
Total gasoline and naphtha	38.2	0.725	63.7	
Kerosene distillate	16.8	.797	46.0	
Gas oil	10.5	.828	39.4	
Nonviscous lubricating distillate	10.8	.837-.854	37.6-34.2	50-100
Medium lubricating distillate	3.1	.854-.859	34.2-33.2	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	19.4	.891	27.3	
Distillation loss	1.2			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51008

IDENTIFICATION

Mayburg field	Clinger Oil and Gas Co.	Pennsylvania
Balltown sand, Upper Devonian	No. 155	Forest County, Kingsley Twp
1,584-1,602 feet	Lot 5215	Sheffield Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.804 A.P.I. gravity, 44.5° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N.P.A. No. 6
Saybolt Universal viscosity at 100°F., 38 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 747 mm. Hg
First drop, 31°C. (88°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp. Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point °C.	S.U. Visc., 100°F.	Cloud test °F.
1	50	122	1.4	1.4)						
2	75	167	2.7	4.1)	0.662	82.2	3.7	61.6		
3	100	212	5.2	9.3	.700	70.6	12	60.0		
4	125	257	8.5	17.8	.726	63.4	15	57.6		
5	150	302	5.8	23.6	.746	58.2	17	57.8		
6	175	347	6.5	30.1	.761	54.4	17	60.8		
7	200	392	5.8	35.9	.773	51.6	17	65.4		
8	225	437	5.4	41.3	.784	49.0	16	70.8		
9	250	482	6.3	47.6	.796	46.3	17	75.8		
10	275	527	6.6	54.2	.808	43.6	18	79.8		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.8	58.0	0.823	40.4	21	84.8	40	20
12	225	437	6.0	64.0	.831	38.8	21	88.6	44	35
13	250	482	5.7	69.7	.843	36.4	23		54	50
14	275	527	4.7	74.4	.850	35.0	23		73	70
15	300	572	4.7	79.1	.858	33.4	24		115	80
Residuum			20.3	99.4	.890	27.5				

Carbon residue of residuum, 1.2 percent; carbon residue of crude, 0.3 percent

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A.P.I.	Viscosity
Light gasoline	9.3	0.683	75.7	
Total gasoline and naphtha	35.9	0.732	61.8	
Kerosene distillate	18.3	.797	46.0	
Gas oil	10.3	.829	39.2	
Nonviscous lubricating distillate	10.6	.838-.855	37.4-34.0	50-100
Medium lubricating distillate	4.0	.855-.862	34.0-32.7	100-200
Viscous lubricating distillate	-	-	-	Above 200
Residuum	20.3	.890	27.5	
Distillation loss	.6			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51009

IDENTIFICATION

Cherry Grove field — Bell Drilling Co. — Pennsylvania
Cherry Grove sand, Upper Devonian — No. 7 — Warren County, Cherry Grove
1,755-1,774 feet — Lot 637 — Sheffield Quadrangle — Twp.

GENERAL CHARACTERISTICS

Specific gravity, 0.777 — A.P.I. gravity, 50.6° — Pour point, °F., below 5
Sulfur, percent, less than 0.1 — Color, N.P.A. No. 5
Saybolt Universal visosity at 100°F., 35 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 759 mm. Hg
First drop, 26°C. (79°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp.Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point °C.	S.U. Visc., 100°F.	Cloud test °F.
1	50	122	6.2	6.2	0.628	93.8	-	-		
2	75	167	4.5	10.7	.660	82.9	2.7	-		
3	100	212	6.9	17.6	.700	70.6	12	41.2		
4	125	257	8.7	26.3	.728	62.9	16	57.4		
5	150	302	6.5	32.8	.747	57.9	18	56.6		
6	175	347	5.9	38.7	.761	54.4	17	60.3		
7	200	392	5.2	43.9	.773	51.6	17	65.2		
8	225	437	5.0	48.9	.784	49.0	16	70.8		
9	250	482	5.1	54.0	.796	46.3	17	74.4		
10	275	527	5.7	59.7	.807	43.8	17	80.0		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.3	63.0	0.818	41.5	19	84.6	39	20
12	225	437	5.0	68.0	.829	39.2	20	88.6	44	35
13	250	482	4.2	72.2	.841	36.8	22		54	50
14	275	527	3.9	76.1	.849	35.2	23		73	70
15	300	572	4.4	80.5	.856	33.8	23		115	85
Residuum			15.7	96.2	.886	28.2				

Carbon residue of residuum, 1.7 percent; carbon residue of crude, 0.2 percent

APPROXIMATE SUMMARY

	Percent	Sp.Gr.	°A.P.I.	Viscosity
Light gasoline	17.6	0.664	81.6	
Total gasoline and naphtha	43.9	0.715	66.4	
Kerosene distillate	15.8	.796	46.3	
Gas oil	8.6	.825	40.0	
Nonviscous lubricating distillate	8.6	.836-.853	37.8-34.4	50-100
Medium lubricating distillate	3.6	.853-.860	34.4-33.0	100-200
Viscous lubricating distillate	-	-	-	Above-200
Residuum	15.7	.886	28.2	
Distillation loss	3.8			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51010

IDENTIFICATION

Cooper field	F. F. Spencer	Pennsylvania
Cooper sand, Upper Devonian	No. 55	Warren County, Howe Twp.
1500 ± feet	Lot 3197	Sheffield Quadrangle

GENERAL CHARACTERISTICS

Specific gravity, 0.807 A. P. I. gravity, 43.8° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N. P. A. No. 4 1/2
Saybolt Universal visosity at 100°F., 39 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 762 mm. Hg
First drop, 30°C. (86°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp. Gr., 60/60°F.	°A. P. I., 60°F.	C. I.	Aniline point, °C.	S. U. Visc., 100°F.	Cloud test °F
1	50	122	1.4	1.4						
2	75	167	2.0	3.4	0.653	85.2	-	59.6		
3	100	212	4.9	8.3	.700	70.6	12	59.2		
4	125	257	8.2	16.5	.728	62.9	16	57.2		
5	150	302	6.3	22.8	.747	57.9	18	57.0		
6	175	347	6.6	29.4	.762	54.2	18	60.2		
7	200	392	6.0	35.4	.773	51.6	17	64.8		
8	225	437	5.6	41.0	.786	48.5	17	70.4		
9	250	482	6.0	47.0	.798	45.8	18	74.7		
10	275	527	6.6	53.6	.810	43.2	19	78.7		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.0	56.6	0.822	40.6	20	82.8	40	15
12	225	437	5.7	62.3	.830	39.0	20	87.0	44	30
13	250	482	5.6	67.9	.842	36.6	23		53	50
14	275	527	4.8	72.7	.851	34.8	24		71	65
15	300	572	5.7	78.4	.859	33.2	25		115	80
Residuum			21.1	99.5	.890	27.5				

Carbon residue of residuum, 1.7 percent; carbon residue of crude, 0.4 percent

APPROXIMATE SUMMARY

	Percent	Sp. Gr.	°A. P. I.	Viscosity
Light gasoline	8.3	0.681	76.3	
Total gasoline and naphtha	35.4	0.734	61.3	
Kerosene distillate	18.2	.799	45.6	
Gas oil	9.7	.820	41.1	
Nonviscous lubricating distillate	10.5	.838-.856	37.4-33.8	50-100
Medium lubricating distillate	4.6	.856-.863	33.8-32.5	100-200
Viscous lubricating distillate	-	-	-	Above-200
Residuum	21.1	.890	27.5	
Distillation loss	.5			

*Published by permission of Director U. S. Bureau of Mines

REPORT OF CRUDE PETROLEUM ANALYSIS
Bureau of Mines Bartlesville Laboratory
Sample 51011

IDENTIFICATION

Balltown field	Mabel Sharp	Pennsylvania
Cooper sand, Upper Devonian	No. ?	Forest County, Cherry Grove
1,474-1,501 feet	Lot 739	Sheffield Quadrangle Twp.

GENERAL CHARACTERISTICS

Specific gravity, 0.796 A.P.I. gravity, 46.3° Pour point, °F., below 5
Sulfur, percent, less than 0.1 Color, N. P. A. No. 4
Saybolt Universal viscosity at 100°F., 37 sec.

DISTILLATION, BUREAU OF MINES ROUTINE METHOD

STAGE 1—Distillation at atmospheric pressure, 762 mm. Hg
First drop, 29°C. (84°F.)

Fraction No.	Cut at °C.	Cut at °F.	Percent	Sum, Percent	Sp. Gr., 60/60°F.	°A.P.I., 60°F.	C.I.	Aniline point °C.	S.U. Visc., 100°F.	Cloud test, °F.
1	50	122	2.4	2.4	0.639	89.9	-	54.2		
2	75	167	3.9	6.3	.655	84.5	0.4	55.8		
3	100	212	5.7	12.0	.698	71.2	11	59.8		
4	125	257	8.4	20.4	.727	63.1	16	57.0		
5	150	302	5.3	25.7	.746	58.2	17	57.0		
6	175	347	6.5	32.2	.761	54.4	17	59.6		
7	200	392	6.9	39.1	.774	51.3	17	65.4		
8	225	437	3.5	42.6	.785	48.8	17	70.2		
9	250	482	5.2	47.8	.795	46.5	16	74.1		
10	275	527	6.7	54.5	.807	43.8	17	78.0		
STAGE 2—Distillation continued at 40 mm. Hg										
11	200	392	3.6	58.1	0.820	41.1	19	82.2	39	15
12	225	437	4.9	63.0	.830	39.0	20	86.4	42	30
13	250	482	5.2	68.2	.840	37.0	22		51	55
14	275	527	4.4	72.6	.849	35.2	23		68	70
15	300	572	5.1	77.7	.857	33.6	24		105	80
Residuum			20.3	98.0	.890	27.5				

Carbon residue of residuum, 1.5 percent; carbon residue of crude, 0.3 percent

APPROXIMATE SUMMARY

	Percent	Sp. Gr.,	°A.P.I.	Viscosity
Light gasoline	12.0	0.672	79.1	
Total gasoline and naphtha	39.1	0.727	63.1	
Kerosene distillate	15.4	.798	45.8	
Gas oil	10.6	.828	39.4	
Nonviscous lubricating distillate	9.5	.839-.856	37.2-33.8	50-100
Medium lubricating distillate	3.1	.856-.861	33.8-32.8	100-200
Viscous lubricating distillate	-	-	-	Above-200
Residuum	20.3	.890	27.5	
Distillation loss	2.0			

*Published by permission of Director U. S. Bureau of Mines

APPENDIX C

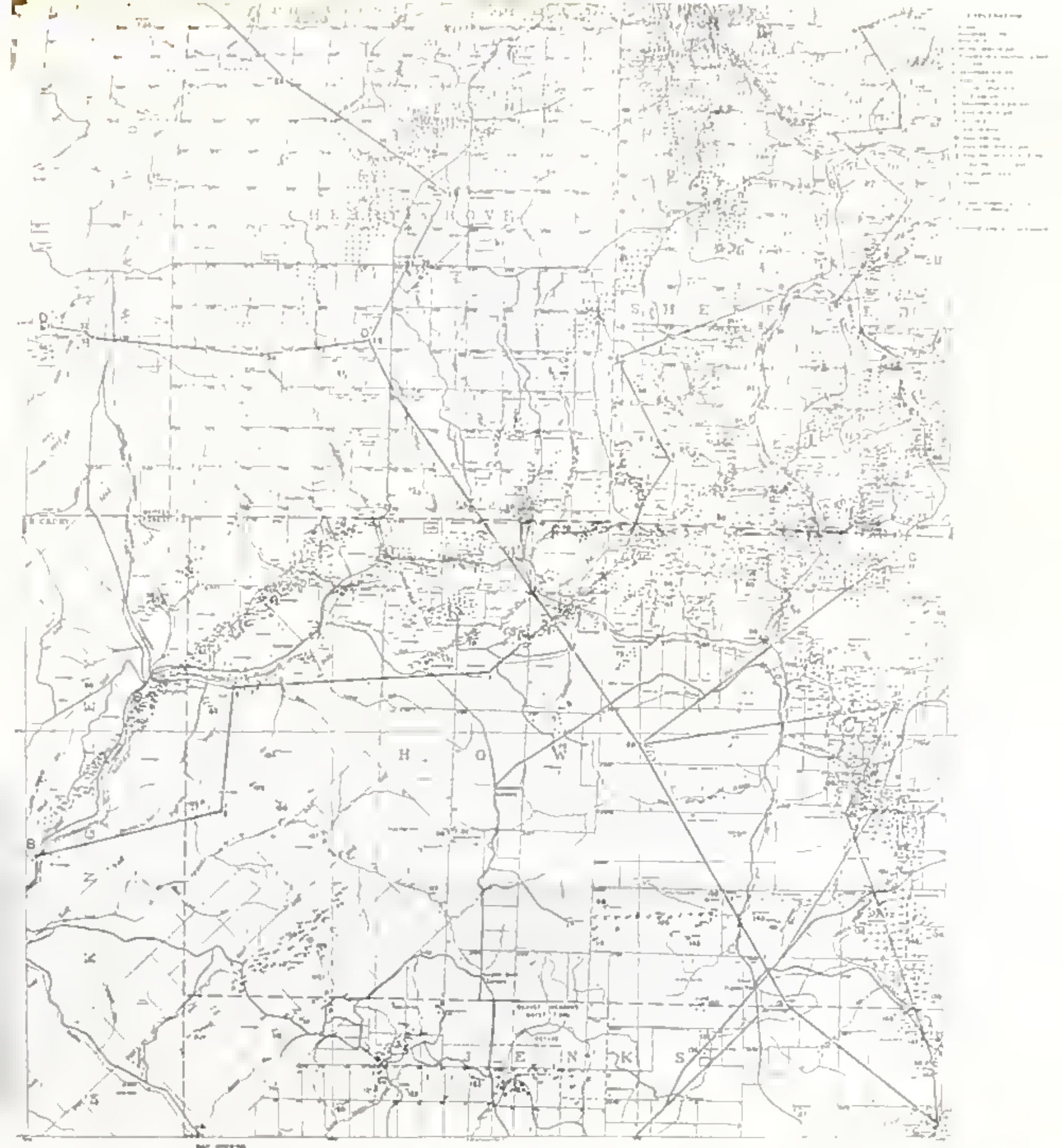
Selected well records in the Sheffield quadrangle

MAP NO.	WELL NAME Lot or Warrant	OPERATOR	ELEVATION	FIRST SAND	RED VALLEY	SECOND SAND	KNOX THIRD STRAY	KNOX THIRD	TANNERS HILL	PINK ROCK	FIRST WARREN	SECOND WARREN	QUEEN-GLAOF	CLARENDON	BALLTOWN	CHERRY GROVE	TIONA	COOPER STRAY	COOPER	KLONDIKE	OEERLICK	SARTWELL	OTHER	TOTAL DEPTH
	1-5268 *	W.F.Clinger	1179							-853	853-855		1068-1140	1231-	1261- P**									1294
2	1-5104	W.F.Clinger	1665				745-760 P		828-877	944-1254		1416-1430 P	1508 1513		1677-1700				1948-					2025
3	172-5286	W.F.Clinger	1198							482-824			1026-1028		1190-1212		1336-1340							1505
4	Fleming 31-319	W.C.Watson	1781				802-836			1020-1350					1754-1827			1970-2024	2024-2044					3025
5	Cooper 84-299	W.F.Clinger	1786				750-			940-1310					1660-1677			1896-	1925-943 P					1963
6	Herrick 38-2715	Forest Chemical	1676			585-615				875-1130	1203-1207				1530-1605 P				1790-1811 P					1838
7	Herrick 32-2872	Mc Neal	1870						900-935	1030-1366					1724-1741		1836-1850		1969-1986		2038-2080			2108
8	Sullivan 4-442	Forest Chemical	1588	605-618			814-842			1038-1388			1610-1620		1737-1763 P				1985-2011 P					2038
9	439-402	Penna Gas	1988				875-1425			1035-1425				1750-1765	1814-1833				2067- P	2126-2141				2141
10	888-366	Penna Gas	1309							400-736					1110-1160				1324-1344 P		1436-1446			1459
11	Bornesville 1-387	Onondaga Gas	1360							450-766			960-1005	1062-1079	1122-1140 P				1375-1385		1500-1525			1600
12	915-317	Penna Gas	1921					724- P					1463-1470 1525-1530	1573-1585	1649-1654 P 1678-1687				1879-1890	1932-1939	2020-2040			2049
13	1065-278	Penna Gas	1855				615-635		710-740	860-1180			1365-1425	1455-1467					1731-1835 P		1918-1930 1936-1940			2039
14	930-27	Penna Gas	1544							510-860			1055-1070		1270-1281 P		1375-1420		1472-1500		1605-1670 P			1712
15	871(3)-248	Penna Gas	1689				435-440		520-570	670-1000				1295-1300	1395-1412 P				1600-1638 P	1658-1677 P	1733-1773			1782
16	223-207	Penna Gas	1808							-1100				1423-		1528-1546					1838-		1918-	1930
17	100-168	Elder	1952											1552-1565		1728-1751					2005-2027 P			2032
18	11-3672	South Penn Oil	1435	343-375		475-501	536-	-574		752-1104			1308-1337	1398-1423	1461-1506 P				1668-1706 P	1757-1768	1821-1846	2278-2286 P		2327
19	1-3801	South Penn Oil	1823	755-787		934-949	983-	-1017	1070-1104	1188-1539				1860-1871					2144-2152					22917
20	1-2993	South Penn Oil	1764	600-634		772-790	817-834	843-845	902-935	1032-1377			1596-1615	1687-1702	1735-1776	1812-1839		1920-1938	1972-2010	2033-2130				22537
21	1-716	Clinger, Goal & Logan	1730	464-515	562-598	654-670		723-735	760-822	904-1260		1361-1410	1487-1512		1612-1666		1776-1790	1811-1834	1867-1889	1944-1950				2052
22	1-695	Clinger, Goal & Logan	1883	552-578	669-695	751-770	801-813	825-837	873-916	996-1352		1476-1497	1574-1603	1693-	-1769	1785-1816	1853-1883	1898-1920	1955-1976	2034-2041				2116
23	1-660	Booth Associates	1808	407-551	605-626	688-710	730-746	752-766	812-849	949-1291		1415-1429	1501-1539	1625-	-1695	1709-1735	1792-1807	1842-1857	1924-1951				2078-2128 2209-2220	3200
24	1-605	Sloan & Zook	1839	432-469	507-537	614-635			745-788	865-1206		1354-1374	1462-1494		1581-1624	1841-1864	1711-1732		1847-1855					1954
25	1-570	Sloan & Zook	1510		177-201		328-334	341-348	416-440	548-895		1034-1042	1138-1174			1327-1342								1432
26	Godfrey 1	Horton & Crary								-1410					1770-1782 1809-1816			1845-	-1985					2180
27	Shaw 2	Cochran	1767							-1330					1698-1630 P 1725-			1890-	1920-1940					1940
28	2-46-2995	Watson Farm	1896							1036-1434			1599-1640	1711-1717	1781-1790 P 1814-1820			1998-						2029
29	32-2882	Duhring Oil								-1395					1760-1796 P									1806
30	34-3671	Duhring Oil	1522							-1207				1586-1590	1691-1697 P			1867-1880	1890-1898			2497-2503 P		2510
31	8-3017	W.F.Clinger	1801	367-383		486-500		566-568	625-	751-1092			1298-1352											1382
32	1-3017	W.F.Clinger	1655					615- P		810-1140			1365-		1522-1580		1610-	-1700	1807-1832					1930
33	1-3064	W.F.Clinger	1639	350-360	535-545	595-604		664-700 P		847-1170			1374-1384 1413-1440		1573-1581	1612-1618	1665-	-1750	1801-1814	1865-1900	1937-1964			1972
34	1-703	Zinger, Goal & Logan	1591		400-410	477-488		543-555	627-635	749-1078			1307-1314		1418-1440 1470-1490	1507-1533	1571-1597	1630-1641	1723-1736					1989
35	1-573	Shaw Bros & Green	1755		408-418	528-543						1278-1308	1392-1425	1492-1522		1600-1625			1800-1840		1906-1916			1936
36	1-3010	W.F.Clinger			340-345	440-				715-1065			1307-1312	1360-1430			1540-1560							1808
37	2-635	Cedar Oil	1725.5		440-456		570-590		610-670	752-1080		1160-1190	1305-1355			1537-1548 P								1540
38	"Mystery Well" 1-646	Jamestown Oil	1805									1320-1345				1610-1630 P								1630
39	8-603	George Conquer	1872							970-1300			1435-1525		1625-1640	1735-1742 P								1735
40	Farnsworth 1958	Landsroth	1085	442-450	535-580					-1215	1215-1250		1490-1520		1600-1625					1842-1850				2004
41	50-205	Warren Group	1568							870-892			1140-1145	1225-1238 P										1253
42	97-163	South Penn Oil	1360											384-1004 P		1086-1110 P								1128
43	8-242	South Penn Oil	1348											1631-1651 P		1765-1782								2113
44	12-245	Horton & Crary	1563											1222-1230 P							1620-1636			1657
45	4-197	Horton & Crary	1942										1430-1450	1565-1590	1640-1650						1987- P			1987 P
46	890-247	Penna Gas	1610							610-960				1260-1290	1335-1341		1400-1425		1545-1586 P		1657-1664			1695
47	935-286	Penna Gas	1544						390-430	545-895					1205-1225				1476-1501 P				Old Stray P 1178-1195	1645
48	1-286	Warren Gas	1514																1497-1507 P					1560
49	Pickett, Shaw 21-284	Grooch Bros	1716											1393-1402 P					-	1740-1742 P				1797
50	Cooper (E)-305	John Wolfe	1759					575-585						1452-1457 P					1772-1777					1847

* First figure indicates well number, second, or second and third figure indicates lot and/or warrant number
** P - Producing sand

MAP NO.	WELL NAME Lot or Warrant	OPERATOR	ELEVATION	FIRST SAND	RED VALLEY	SECOND SAND	KNOX THIRD STRAY	KNOX THIRD	TANNERS HILL	PINK ROCK	FIRST WARREN	SECOND WARREN	QUEEN-GLADE	CLARENDON	BALLTOWN	CHERRY GROVE	TIONA	COOPER STRAY	COOPER	KLONDIKE	DEERLICK	SARTWELL	OTHER	TOTAL DEPTH
51	183-318	Penna Gas	1901											1550-1568	1624-1636 1670-1682			1858	1873-1880 P		2000-2017			2020
52	2-356	CW Bramer	1844											1513-	1588- P 1612-				1824- P					1834
53	21-362	Horton & Crary	1876											1624-			1825- P			1953- 1976-1985 P				1996
54	1-688	Horton & Crary	1903					775-		-1319									1975-	2015- 2025-2035 P				2051
55	138 365	Penna Gas	1664					523-		-1098									1679-1701 P					1712
56	9-3064	WF Clinger	1766	549-569	615-623	667-685		742-747 P																781
57	1-705	Clinger, Goal & Logan	1751		526-535			700-722 P																727
58	136 5235	WF Clinger	1509							750-1100			1275-1375	1405-1430	1488-1507 P								Knox 4, 610- Knox 5, 640-	1526
59	154-5216	WF Clinger	1481												1442-1465	1510-								1541
60	82-5215	WF Clinger	1187												1207-1234 P									1248
61	163-5236	WF Clinger	1187	87-						486-838			1014-1078		1210-1234 P									1255
62	150-5236	WF Clinger	1430												1400-1426 P									1446
63	184-5266	WF Clinger	1425	340-350					579-627	715-1055					1426-1452 P			1660-1670	1696-1713					1753
64	43-4821	WF Clinger	1713					750-770		940-1280				1600-1650	1665-1685 P									1710
65	289-709	Penna Gas	1784												1590-				1790-1800					1842
66	501-403	Penna Gas	1838							950-1300					1635-1665 P				1924-1941 P					2046
67	165-715	Penna Gas	1640												1488-1503				1743-1763					1761
68	66-742	South Penn Oil	1487												1384-1404 P									1416
69	510-739	Sharp & Gool	1356												1235-1255 P ?			1460-	1489-1515 P					1525
70	27-3198	Northern Ordnance	1356					316-356							1230-1270 P			1493-1510	-1534 P		1586-1614			1619
71	21-2991	WF Clinger	1784																1946-1956 P					1975
72	Clapp (South) 6-3193	Atkinson	1786																1938-1961 P					1961
73	Balltown Farm 8-3197	Spencer	1536												1444-1474 P									1475
74	13?-3198	Northern Ordnance													1150-1196 P			1402- P						1457
75	68-3193	Wasson	1808					814-850 P							1713-1825 P			1977-2004	2010-2033 P					2037
76	28-3192	Wasson	1776					794-838							1716-1740 P									1750
77	Ray 21-4791	Wasson	1938						795-845	940-1260					1659-1705 P			1910-1918						3520
78	Crissman S 3-3197	Spencer	1942												1207-1236 P				1465-1498 P		1590-1594			1625
79	Porcupine 87 3194		1716												1635-1657 P									1663
80	309-401	Penna Gas	1826					724-744	835-855	930-1270			1400-1425 1455-1470	1582-1600	1630-1650		1745-1755	1830-1847	1857-1870 P	1885-1912				2014
81	6-397	J Cochran	1332											1057-1067				1380-1388	1397-1409 P					1423
82	1-405	Penna Oil	1290							461-800					1126-1146				1387-1403				Haskill 2187-2215	2275
83	48-408	Cochran	1365?							479-822				1097-	1203-				1410 P				Mageehollow 416-	1433
84	65 440	Hickey	1373												1298-1306				1472- P					1480
85	31 438	Cochran	1767															1844-	1864-1888 P					1896
86	2 430	Haddon	1440												1204 1260- P				1450-1466 P					[illegible]
87	Bunch 11-2	Hickey et al	1676					830-850							1805-1817 P									[illegible]
88	Grandin 16-	South Penn Oil																	1935-1955 P					[illegible]
89	Enterprise 41-	Cochran	1744												1666-1689 P				1887- P					[illegible]
90	4-	Haddon	1738					669-		900-1230					1590- 1630			1827-1837	1847-1867 P					1882
91	Barnes Old 2	Cochran	1741							910-1234				1520-1535	1570- 1655-1663				1855-1880				Mageehollow 850	1880-
92	Davis 14-7	Cochran	1879												1748 P 1797-1850				2000-					[illegible]
93	Godfrey 21-	South Penn Oil	1748											1575-1590	1640-1650 1698-1706 P									[illegible]
94	Tionesta 47-	South Penn Oil													1468-1478				1669-1680 P					1680
95	Blue Jay 37-1	Jones																	1888-[illegible] P					[illegible]
96	Anchor 13	South Penn Oil	[illegible]																1917-1948 P					[illegible]
97	Bell 1	Atkinson	1704																1861-1884 P					[illegible]
98	Blue Jay Fox 1-5		1260±	75-95				230-260					980-1005		230-1255 P			330-1445	445-1459					[illegible]
99	Tionesta 27-28 2	South Penn Oil													305-1312 P				[illegible]					
100	Tionesta 36-	South Penn Oil	1707												1688-1699 P				1492-[illegible]					

MAP NO	WELL NAME (or Warrant)	OPERATOR	ELEV-ATION	FIRST SAND	RED VALLEY	SECOND SAND	KNOX THIRD STRAY	KNOX THIRD	TANNERS HILL	PINK ROCK	FIRST WARREN	SECOND WARREN	QUEEN-GLADE	CLARENDON	BALLTOWN	CHERRY GROVE	TIONA	COOPER STRAY	COOPER	KLONDIKE	DEERLICK	SARTWELL	OTHER	TOTAL DEPTH
101	Blue-Jay 11-2995	South Penn Oil	1340												1340-1354 P				1552-1553					1566
102	7-2	Cochran	1860												1765-1800-				2003-2024					2040
103	8-5104	W F Clinger	1834				736-754			958-1000		1383-1435 P	1492-1532											1560
104	10-5101	W F Clinger	1830				761-776			993-1027									1874-2050 P					2059
105	22-5104	W F Clinger	1811				869-901 P			1068-1354		1556-1568 P												2156
106	26-5104	W F Clinger	1551	396-401	517-533		629-635		701-765	835-1185		1230-1312 P												1342
107	4-5104	W F Clinger	1430	265-312	373-		542-557		557-585	734-1074		1156-1163 P	1256-1293		1445-1463 P				1683-1731					1751
108	35-5106	W F Clinger	1794		739-765		870-877	882-889 P															Knox in P 908-918	961
109	32-5106	W F Clinger	1850		785-866		923-936	946-950	1020-1075	1158-1493			1680-1714		1859-1883									1977
110	7-5108	W F Clinger	1820				928-943	950-983	1006-1048	1140-1490			1643-1692		1854-1862	1933-1947		2041-2058	2088-2103					2223
111	5-5107	W F Clinger	1862				978-984			1202-1548			1782-1790		1805-1931 P					2130-2139				2221
112	15-5107	W F Clinger	1813	673-683			925-971		1006-1041	1152-1480					1857-				2058-2103					2203
113	2511-5123	United Nat Gas	1737				870-971												2117-2131					2490
114	Morey 4-5123	W F Clinger	1260±				500-520								1487-1524				1647-1665					1728
115	Collins 1-3183	Wesson	1830									1538-1550	1648-1658			1885			-2055	-2165			Tully 4786-804 Onek 5192-5209	5349
116	3-3186	Marienville Gas	1814					872-							1772-				2054-2065					2116
117	28-5102	South Penn Oil	1570				680-690			883-930		1208-1339		1563-1569	1577-1665				1817-1848					1860
118	16-3803	McNeal	1777				877-892																	909
119	20-3803	McNeal	1603	714-723			922-952 P			1170-1505					1790-1810		1950-1960		2077-2119					2126
120	Bonner 1-48-3179	South Penn Oil	1549				681-724			915-1250					1600-1800				1667-1685					1368
121	6-37-3181	South Penn Oil					801-805								1809-1828 P									3026
122	Bonner 1-36-3181	South Penn Oil	1586				838-	855-		995-1400					1860-1899									2201
123	Bonner 1-21-3181	South Penn Oil	1818				971-981										2016-2042 P							2100
124	22-20-3182	Marienville Glass	1634	585-595			869-884		958-986	1110-1433							1926-1944							1946
125	7-54-2736	W P Bell	1783												1739- P									1815
126	2-58-2736	Duhring Dev	1734							-1365					1760-1768 P									1781
127	5-56-2736	Marienville Oil	1776												1813- P									1826
128	12-31-2882	Duhring Dev	1760												1734-1802 P									1818
129	10-3803	McNeal	1760	640-645			865 870 P																	870
130	2-3803	South Penn Oil	1615±				715-736 P								1650-1655				1859-1866					2405
131	7-3802	McNeal	1736				846-862 P			1070-1400					1767-		1841-1851	1940-1963	1985-2008					2019
132	Collum 29-2018	South Penn Oil	1564						780-	930-					1639- P									1667
133	Collum 17-2018	South Penn Oil	1723						950-	1050-					1807- P									1833
134	17-2018	Duhring Dev	1592												1662-1671 P									1682
135	191-3800	Murphy	1785																2020-2040	2085-2113	2150-2200			2305
136	1-3800	Benedum & Trees	1807	745-755	878-885		1000-1018	1040-1062	1100-	-1570			1803-1812	1908-1920		1999-2029	2056-2075	2114-2137	2148-2200		2255-2360		Tully 2378-2445 2528-2572 2681-2697	3002
137	388-3644	Penna Gas	1780	703-711						1214-1550									2143-2149 P	2210-2225	2240-2269			2306
138	34-2022	South Penn Oil													1676-1684 P									1711
139	Duhring 6-3672	South Penn Oil	1591				833-846						1478-1486		1652-1663 P				1832-1872 P					1872
140	5-3799	Duhring Dev	1689				861-873 P																	895
141	9-3802	McNeal					857-874																	874
142	6-3802	McNeal					707-718																	718
143	4-3803	South Penn Oil	1740				831-855 P																	963
144	24-3671	Duhring Dev	1738				856-900								1815-1824 P							2621-2692 P		2695
145	3-3671	Duhring Dev													1520-									1520
146	3-2021	South Penn Oil	1650												1744-1747 P				1934-1945				2478-2501 2582-2602	2626
147	24-2022	South Penn Oil	1720												1787-1793 P									1815
148	10-2018	Duhring Dev													1632-								2395-2415 2630-2650	2790
149	19-40-2882	Duhring Dev													1785-1791 P									1804
150	30-2882	Duhring Dev													1670-1677 P									1687


LINES OF CROSS SECTIONS
AND
ROCK TO WELL LOCATIONS FOR SELECTED WELL RECORDS

SHEFFIELD QUADRANGLE

FOREST AND WARREN COUNTIES
PENNSYLVANIA

SHOWING PRODUCING OIL AND GAS SANDS
AND OTHER LITHOLOGIC UNITS

SYSTEM	SERIES	GROUP	FORMATION OR MEMBER	PRODUCTION	GRAPHIC LOG	THICKNESS	REMARKS
PENNSYLVANIAN	POTTSVILLE		BROOKVILLE COAL			50'	
			HOMEWOOD				
			MERCER SHALE-COAL				
			CONNOQUENESSING			245±	
			SHARON				
			OLEAN				
MISSISSIPPIAN		POCONO	PATTON			45'±	Found only in southern part of quadrangle. Removed by erosion in northern part.
			SHENANGO-CUYAHOGA			200'	
			CORRY ← ?			500'	Stratigraphic position of the Corry is uncertain. It may be equivalent either to uppermost Knapp beds, or section just above Knapp.
			KNAPP			140'	
		CONEWANGO	RICEVILLE (OSWAYO)			95'	
			? VENANGO FIRST	*			Top of the first Cattaraugus red bed is found at approximately 370 feet above top of Pink Rock throughout much of quadrangle. In extreme southern part of quadrangle, however, most of the red except for the Tanners Hill bed, has disappeared.
			RED VALLEY				
			(VENANGO) CATTARAUGUS			360'	Nomenclature of the Conewango group corresponds with that used in Oil City report (Pa. G.S. Bulletin M 25, 1943).
			VENANGO SECOND			1000'	
			AMITY SHALE				Amity shale is persistent unit found just below the Venango Second sand.
			KNOX THIRD STRAY	*			
			KNOX THIRD	*			
			KNOX FOURTH				
			KNOX FIFTH				
			TANNERS HILL RED				The Tanners Hill red shale is a persistent and very excellent marker bed found throughout the quadrangle
		CONEAUT	MAGEE HOLLOW	*		90'	
			PINK ROCK			390'	The so-called Pink Rock of the driller like the Tanners Hill Red above is a widespread and excellent marker found throughout the quadrangle. Published studies indicate it to be present at least as far west as the Oil City quadrangle, Venango County and east to the eastern part of McKean County. The base of the Pink Rock is the contour horizon of the accompanying structural map.
			FIRST WARREN			1500'	
			SECOND WARREN	*		270'	
			QUEEN "50 FOOT" GLADE	*			The Queen sand zone ("50 Foot" of the driller) is a slightly localized and erratic unit. The Glade sand of Warren and Sheffield quadrangles correlates with the basal part of the zone.
			CLARENDON STRAY	*			
			CLARENDON	*			The Balltown is divided into an upper and a lower unit. The lower unit correlates with the Second, Dunkirk and Watson sands of the eastern part of the Sheffield quadrangle.
			BALLTOWN { SECOND DUNKIRK WATSON }	*		2000'	
			CHERRY GROVE ◦	*			
			TIONA	*		480'	The name "Tiona" corresponds with usage to the south and west. The locality named "Tiona" sand near Tiona, Sheffield quadrangle, is the Clarendon sand.
			COOPER STRAY	*			The Coneaut Stray-Cooper sand zone is locally intersand in the south-central part of the quadrangle.
			COOPER ◦	*			
		CANADAWAY	KLONDIKE	*			
			DEERLICK	*			
			BRADFORD THIRD				Approximate horizon of Bradford Third sand
			LEWIS RUN				Approximate horizon of Lewis Run sand
			KANE SANDS			2300'	Position of Kane sands only approximate. Little data is available on these sands in the quadrangle.
			SARTWELL ?	◦			The Sartwell sand is the driller's "Elk" sand. Tentatively called the Sartwell, it may correlate with the sand of that name in eastern McKean County.
			HASKILL				Approximate horizon of Haskill sand

LEGEND

◦ OIL
* GAS
* OIL AND GAS
◦ PRINCIPAL PRODUCING SANDS

GEOLOGY COMPILED
1941-1955

Pennsylvania Geological Survey
4th Series, Bulletin M 35
Plate 7